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BEVERLY T. GALLOWAY, Director

Departments of Plant Pathology and Entomology

DUSTING AND SPRAYING EXPERIMENTS WITH APPLES

BY DONALD REDDICK AND C. R. CROSBY



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Ithaca, New York, November 1, 1915

DIRECTOR B. T. GALLOWAY,
College of Agriculture,
Ithaca, New York.

Dear Sir:

We beg to submit herewith a report of work done under the Herman Frasch Industrial Fellowship, with the recommendation that it be published as Experiment Station Bulletin 369.

The work was performed during the summer of 1915 in the orchards of E. W. Mitchell, at Stuyvesant Falls, New York; W. P. Rogers & Co., at Williamson, New York; Jacob Jungbluth, at Spencerport, New York; Fred H. Glidden & Son, at Holley, New York; and E. J. McClew & Sons, at Newfane, New York. The writers are indebted to these men for cooperation in placing the orchards at their disposal, and for liberally aiding them in the work in every way possible.

Assistance in various technical details of the experiments has been given by L. A. Toan, Manager of the Monroe County Farm Bureau, and by M. D. Leonard, S. C. Bishop, and H. Braun, of Cornell University. The materials were furnished by the Union Sulfur Company, of New York City, and the Corona Chemical Company, of Milwaukee, Wisconsin; the dusting machines were furnished by the Kansas City Dust Sprayer Manufacturing Company.

Respectfully submitted,

DONALD REDDICK,
Professor of Plant Pathology.

C. R. CROSBY,
Professor of Entomology.

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DUSTING AND SPRAYING EXPERIMENTS WITH APPLES

DONALD REDDICK AND C. R. CROSBY

INTRODUCTION

Results of a series of experiments performed by Blodgett¹ and by the writers² indicate that the application of suitable powdered materials, with air used as a carrier, will control the apple scab disease and certain apple insects as well as does the commonly employed fungicide and insecticide applied as a spray with water as a carrier. Some doubt has been expressed as to the validity of these conclusions, owing to the failure to secure satisfactory scab control in two orchards and to the absence of codling moth injury in most of the experiments. The work herein reported, which is a direct continuation of previous work, was undertaken for the purpose of confirming the earlier conclusions. The orchards selected for the experiments are widely separated, and it was therefore hoped that severe test conditions would prevail in some of them. If fairly severe infestation occurred in all the orchards, any results obtained would be of immediate general application.

OBJECTS OF THE EXPERIMENTS OF 1915

On the basis of work previously accomplished, the following points of determination were regarded as important in these experiments:

1. Previous work indicated that satisfactory insect control could be secured with a dust mixture containing ten per cent of arsenate of lead, when from two to three pounds of the mixture was applied to large bearing trees. In six of the experiments, therefore, it was planned to use that percentage of lead arsenate in at least two of the test plats. In the Mitchell orchard it was planned to vary the quantity of lead arsenate per tree by decreasing the amount of dust applied. In a number of other cases a similar variation finally resulted, owing to the dissimilarity in flowing quality of the different mixtures used.

2. The quantity of sulfur³ applied per tree in all previous tests has been far in excess of the actual sulfur applied in lime-sulfur solution. Further

¹ Blodgett, F. M. Experiments in the dusting and spraying of apples. Cornell Univ. Agr. Exp. Sta. Bul. 340:149-179. 1914.

² Reddick, Donald, and Crosby, C. R. Further experiments in the dusting and spraying of apples. Cornell Univ. Agr. Exp. Sta. Bul. 354:53-96. 1915.

³ In all the experiments a finely ground flour sulfur, now known commercially as superfine sulfur, was used. This product is ground to such a fineness that at least 95 per cent will pass a screen of 200 meshes to the inch. If crude sulfur were ground to the same degree of fineness, it would doubtless prove equally effective and would cost less. The arsenate of lead used was of the so-called fluffy type, the individual particles of which are much smaller than the majority of the particles of sulfur.

tests were made in order to determine whether the quantity of sulfur per tree could be reduced. These tests have involved, on the one hand, the use of diluents which would keep the gross quantity of material per tree the same, and, on the other hand, the application of reduced quantities of sulfur. In the latter case the quantity of lead arsenate applied per tree was kept the same as in the other plats by increasing the percentage in the mixture.

3. Can the destructive properties of the dust mixture be increased by the addition of some other material? This might be accomplished by adding an inert substance that would bring about better adhesion of the sulfur and lead arsenate, or by adding a substance having inherent fungicidal or insecticidal properties. The substances tried were: (1) hydrated lime, a material imperfectly tested in 1914; (2) finely ground gypsum, known commercially as *terra alba*, a material used as a diluent in 1914 with satisfactory results; (3) finely powdered soap, a material commonly used to increase the spreading properties of liquids and as a contact insecticide; (4) casein and lime, the adhesives in cold water paint.

4. A fourth important point, peculiar to an experiment of this type, is to determine whether it is possible to so forecast weather conditions that applications of fungicides can be made at critical times.

The experiments of the season, therefore, hinged about these four primary considerations. Incidentally, additional data were obtained on the time required for application under commercial conditions.

Comparisons were made of the various dusted plats with a plat of trees treated with the standard spray materials, lime-sulfur solution and lead arsenate, and with a plat of trees that received no summer treatment. Details as to quantities of material used, dates of application and conditions influencing the same, time required, comparative costs, and results, are given in connection with the individual experiments.

WEATHER CONDITIONS AND APPLE SCAB INFECTION PERIODS

The weather conditions for the season, in so far as there are records having a bearing on the work, are shown in table 1. These records are taken from the monthly Meteorological Summary of the United States Weather Bureau at Rochester, and represent in a general way the conditions for western New York. From numerous inquiries the writers are satisfied that these data represent fairly accurately the conditions that existed in all the orchards, so far as infection periods for disease-producing fungi are concerned.

TABLE I. TRANSCRIPT OF RECORDS TAKEN BY THE UNITED STATES WEATHER BUREAU AT ROCHESTER

Date	Precipitation (inches)	Weather conditions
May 1	.03	Cloudy
May 2	T*	Cloudy
May 3	T	Partly cloudy
May 4	.09	Cloudy
May 5	.04	Cloudy
May 7	.62	Cloudy
May 9	T	Cloudy
May 12	0	Cloudy
May 13	.50	Cloudy
May 16	.21	Cloudy
May 17	0	Cloudy
May 18	0	Partly cloudy
May 20	.02	Cloudy
May 21	.42	Cloudy
May 22	0	Cloudy
May 23	0	Cloudy
May 24	0	Partly cloudy
May 25	.12	Partly cloudy
May 26	.05	Cloudy
May 28	0	Cloudy
June 2	0	Cloudy
June 3	0	Cloudy
June 7	.03	Partly cloudy
June 8	.14	Clear
June 9	T	Partly cloudy
June 10	0	Partly cloudy
June 11	.15	Cloudy
June 13	.02	Partly cloudy
June 15	.65	Cloudy
June 18	0	Cloudy
June 19	.37	Partly cloudy
June 20	.01	Partly cloudy
June 22	.29	Cloudy
June 23	.09	Cloudy
June 25	T	Partly cloudy
June 29	0	Partly cloudy
June 30	.54	Cloudy
July 1	T	Partly cloudy
July 2	0	Cloudy
July 3	.35	Cloudy
July 4	0	Partly cloudy
July 5	.27	Cloudy
July 6	0	Partly cloudy
July 7	.11	Cloudy
July 8	.99	Partly cloudy
July 10	0	Partly cloudy
July 11	.06	Cloudy
July 12	0	Partly cloudy
July 13	T	Partly cloudy
July 15	T	Cloudy
July 16	.03	Cloudy
July 17	0	Partly cloudy

*Trace; an amount less than .01 inch, too small to be measured.

TABLE 1 (concluded)

Date	Precipitation (inches)	Weather conditions
July 18.....	T	Clear
July 19.....	T	Cloudy
July 21.....	0	Partly cloudy
July 22.....	T	Partly cloudy
July 25.....	T	Cloudy
July 26.....	.40	Cloudy
July 27.....	0	Partly cloudy
July 28.....	.39	Cloudy
July 29.....	0	Partly cloudy
July 30.....	.08	Cloudy
July 31.....	0	Partly cloudy
August 1.....	0	Partly cloudy
August 2.....	0	Cloudy
August 3.....	.99	Cloudy
August 4.....	.47	Cloudy
August 5.....	.01	Clear
August 6.....	.03	Cloudy
August 7.....	T	Partly cloudy
August 8.....	1.10	Partly cloudy
August 9.....	.02	Partly cloudy
August 10.....	0	Partly cloudy
August 12.....	.34	Cloudy
August 13.....	0	Partly cloudy
August 14.....	0	Partly cloudy
August 15.....	.06	Partly cloudy
August 16.....	0	Partly cloudy
August 17.....	0	Partly cloudy
August 21.....	.73	Cloudy
August 22.....	.11	Cloudy
August 23.....	0	Cloudy
August 24.....	.25	Partly cloudy
August 25.....	0	Cloudy
August 26.....	0	Partly cloudy
August 27.....	0	Partly cloudy
August 28.....	.02	Cloudy
August 29.....	.20	Cloudy
August 30.....	.01	Cloudy

Storm periods were of frequent occurrence throughout the growing season. A comparison with the average, however, shows that there was a deficiency in total rainfall in the months of April, May, June, and July. The rainfall for the month of April was 1.38 inches below normal; only 1.06 inches of water fell. This dry period seems to have been very unfavorable for the proper development of most parasitic fungi, for primary infections of a number of the common disease-producing fungi were not so abundant as was anticipated from the abundance of overwintering material and the subsequent favorable infection weather. The apple scab fungus was not mature as early as usual, nor in its expected

abundance; so that no infection occurred until the trees were in full bloom (May 16), although very favorable conditions existed in the last four days of April and the first five days of May, and again on May 7.

On May 16 excellent weather conditions for infection prevailed, and on this date, wherever the scab fungus was present in the fallen leaves, the first infections of the season occurred. Additional primary infections occurred on May 20 and 21. On May 26 the weather was exceedingly favorable for infection, and examinations made by experts in the various apple counties of western New York showed that the first lesions of apple scab (from the infection of May 16) were appearing on that date. Unfortunately for the experiments, these lesions were not sufficiently developed to give the maximum amount of new infection.

There were a number of periods in June which were fairly favorable for secondary infections (June 7 and 8, 15, 19, 20, and 22 and 23), but no notably favorable conditions came until June 30.

A comparison of the records for June and July would indicate that the two months were much alike. The storm periods in July, however, were much more favorable for infection, because of mist and fog. Following the heavy rain of June 30 the first eight days of July constituted a continuous period of infection. The traces of rain on July 15 and subsequent days prompted a treatment of the orchards beginning on July 20 and ending in time to give protection against infection periods occurring on July 26 and from the 28th to the 30th. There were several periods in August favorable for infections, those from the 3d to the 9th and from the 28th to the 30th being especially favorable.

Frosts occurred on May 3, 10, 15, and 20; and following the rain and fog of May 26 there was a drop in temperature until at four o'clock in the morning of May 27 the thermometer registered as low as 26° F. in various parts of the fruit belt.

The result of this severe freeze was that the set of fruit in some of the experimental orchards was nearly ruined. In the orchards at Newfane and Holley the crop in some of the plats selected for the work was practically destroyed. The orchards were not abandoned, however, because some of the plats showed promise of having a fair yield.

EXPERIMENT IN THE MITCHELL ORCHARD AT STUYVESANT FALLS

The experimental orchard at Stuyvesant Falls consisted of a block of Baldwin trees twelve rows square, with apple trees of other varieties on two sides and pear trees on one side, as shown in figure 69. The block comprised an area with space for one hundred and forty-four trees set forty feet apart each way, but owing to a series of very severe winters a

number of the trees were dead or dying; some of the trees had been killed in the preceding winter. The land is nearly level, and the soil, which is a rich loam, is well tilled each spring and is seeded to a cover crop in late July.

The black lines in the illustration separate the variously treated plats, which are designated by arabic numbers in the upper right-hand corners; the letters set in bold-faced type indicate the trees from which counts were made.

A prearranged system of selecting count trees could not be followed, because of missing trees or trees the use of which would have been obviously unfair to the test.

	X	X	X	X	X	X	X	X	X	X	X	X	X
X	B	B	B	1	B	B	B	3	B	B	O	4	P
X	B	B³	B⁴	B	B	B	B		O	B	B	B	P
X	B	B²	B	B	B	B	B		O	B	B	B	P
X	B	B¹	B	B	B	B	B		B	B	B	O	P
X	B	B	B	2	B	B	B	B	B	O	B	B	P
X	B	B	B	B	B	B	B	B⁴	B	B	O	O	P
X	B	B	B	B	B	B	B		O	O	B	B	P
X	B	B	B⁴	B	B	B	O	B³	O	O	B³	B	P
X	B	B³	B	B	B	B²	B		B	B	B	B²	P
X	B²	B	B	B	B	B	B¹	B	O	B⁴	O	B¹	P
X	B	B	B	B	O	O	B	B	O	O	B	B	P
X	B	B¹	B	B	O	B	B	O	O	O	O	B	P

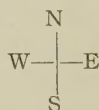


FIG. 69. PLAN OF EXPERIMENT PERFORMED IN THE MITCHELL ORCHARD, STUYVESANT FALLS, NEW YORK

The blocks of trees enclosed in the black lines represent the various plats as indicated by the numbers in the upper right-hand corners. Plat 1, untreated; plat 2, sprayed; plats 3 and 4, dusted with varying proportions of sulfur mixtures. The trees indicated by bold-faced type are the trees from which apples were counted; the exponents refer to the order in which the data are presented in the table. B, Baldwin; P, pears; X, other varieties of apples; O, missing trees.

METHODS AND MATERIALS USED

The spraying solution used in the experiment in this orchard was applied with a power spraying outfit having a pressure of about 150 pounds. Two men and a team were used to operate the sprayer. Two lines of hose were used; one man sprayed from a tower, the other man from the ground. The dust mixtures were applied with a power outfit operated by an old gasoline engine rated at 2 horse power.

A treatment with scale-strength lime-sulfur solution was given to the entire block at the time when the buds first showed green. Four summer applications were made. The first of these was made when the blossom buds showed pink. The second was made before all the blossoms had fallen; the clinging blossoms doubtless offered considerable obstruction to efficient work, but considering the very favorable scab infection weather it was thought best not to delay the application, especially as eighteen days had elapsed since the first application. The third application was made three weeks after the calyx treatment, and the fourth ten weeks after the calyx treatment. All treatments, in each application, were made on the same forenoon, and no external factors entered to mar execution of the general plan of the work.

In table 2 are shown the dates, quantities of material used, and other data, for the different applications. The cost figures are calculated on the basis of horse labor at 10 cents an hour, man labor at 20 cents an hour, lime-sulfur solution at 12 cents a gallon, sulfur at \$2.85 a hundredweight, dry arsenate of lead at 18 cents a pound, terra alba at 40 cents a hundredweight.

The figures are somewhat arbitrarily chosen and may not represent the actual conditions existing on any of the farms. They do not correspond exactly with those employed in two former bulletins, and comparisons between this bulletin and former ones must be made with that point in mind. The cost of deterioration of outfit is not taken into account, and time lost in making adjustments of various kinds is not included in the record.

The relative cost per tree is subject to some fluctuation, but less so than in former work. In this table no time is allowed for filling the spray tank and for driving to and from the orchard. A record is available, however, showing that just as much time was required to fill the tank and drive to the orchard as to empty the tank. Since the labor item is of considerable consequence in spraying, the cost per tree for spraying should be increased very materially.

All applications of spray and dust were made from both sides of the trees and were thorough. No effort was made to apply the dust to the foliage while it was still moist with dew, but on at least two occasions the leaves were moist.

It may be seen from the table that the cost of applying the dust mixtures was considerably less than that of applying the liquid, but that the dry materials were more expensive. The total cost per tree is somewhat in favor of spraying, but when the labor of filling is added the cost of spraying is raised to 22 cents per tree. It may be seen also that the dusted trees were covered about four times as fast as were the sprayed trees. These

TABLE 2. DATA ON TIME AND METHODS OF APPLICATION, MITCHELL ORCHARD, STUVESANT FALLS, NEW YORK

Date of application	Plot	Num-ber of trees	Material used, and strength	Quan-tity used	Time required						Cost		
					Horse		Man		Machine		Labor	Ma-terial	Total cost
					Hrs.	Min.	Hrs.	Min.	Hrs.	Min.			
April 29	2	32	Lime-sulfur solution 2.5 gallons, lead arsenate 2.5 pounds, water to make 100 gallons	(Gallons)	1	00	1	00	0	30	\$.30	\$1.20	\$1.50
May 17	2	32		160	1	00	1	00	0	30	.30	1.20	1.50
June 9	2	32		200	1	00	1	00	0	30	.30	1.50	1.80
July 29	2	32		100	1	00	1	00	0	30	.30	.75	1.05
Total..	...	...	.....	620	4	00	4	00	2	00	\$1.20	\$4.65	\$5.85
April 29	3	43	Sulfur 40, lead arsenate 10, gypsum 50	(Pounds)	0	34	0	34	0	17	\$.17	\$2.83	\$3.00
May 17	3	43		100	0	42	0	42	0	21	.21	3.14	3.35
June 9	3	43		80	0	34	0	34	0	17	.17	2.49	2.66
July 29	3	43		60	0	34	0	34	0	17	.17	1.88	2.05
Total..	...	...	.....	330	2	24	2	24	1	12	\$.72	\$10.34	\$11.06
April 29	4	30	Sulfur 40, lead arsenate 10, gypsum 50	(Pounds)	0	32	0	32	0	16	\$.16	\$1.57	\$1.73
May 17	4	30		45	0	44	0	44	0	22	.22	1.41	1.63
June 9	4	30		40	0	28	0	28	0	14	.14	1.26	1.40
July 29	4	30		40	0	30	0	30	0	15	.15	1.26	1.41
Total..	...	...	.....	175	2	14	2	14	1	07	\$.67	\$5.50	\$6.17
April 29	4	30	Sulfur 40, lead arsenate 10, gypsum 50	(Pounds)	0	32	0	32	0	16	\$.16	\$1.57	\$1.73
May 17	4	30		45	0	44	0	44	0	22	.22	1.41	1.63
June 9	4	30		40	0	28	0	28	0	14	.14	1.26	1.40
July 29	4	30		40	0	30	0	30	0	15	.15	1.26	1.41
Total..	...	...	.....	175	2	14	2	14	1	07	\$.67	\$5.50	\$6.17
April 29	4	30	Sulfur 40, lead arsenate 10, gypsum 50	(Pounds)	0	32	0	32	0	16	\$.16	\$1.57	\$1.73
May 17	4	30		45	0	44	0	44	0	22	.22	1.41	1.63
June 9	4	30		40	0	28	0	28	0	14	.14	1.26	1.40
July 29	4	30		40	0	30	0	30	0	15	.15	1.26	1.41
Total..	...	...	.....	175	2	14	2	14	1	07	\$.67	\$5.50	\$6.17
April 29	4	30	Sulfur 40, lead arsenate 10, gypsum 50	(Pounds)	0	32	0	32	0	16	\$.16	\$1.57	\$1.73
May 17	4	30		45	0	44	0	44	0	22	.22	1.41	1.63
June 9	4	30		40	0	28	0	28	0	14	.14	1.26	1.40
July 29	4	30		40	0	30	0	30	0	15	.15	1.26	1.41
Total..	...	...	.....	175	2	14	2	14	1	07	\$.67	\$5.50	\$6.17

figures are not entirely reliable, however, for, as may be seen from the table, almost as much time was consumed in dusting a block of forty-three trees as in dusting another block of thirty trees. The reason for this difference is that the team walked at a certain speed regardless of whether trees were missing or not. On an average, 0.538 minute was required per tree to make an application of dust in this orchard.

The relative quantities of the essential fungicidal and insecticidal ingredients applied per tree are of interest. The amount of sulfur applied to the sprayed trees cannot be determined exactly,⁴ but was, on an average, approximately 4.6 ounces per tree, with 1.93 ounces of arsenate of lead. Trees in the plat dusted with the smaller amount of the mixture received on an average 9.3 ounces of sulfur and 2.33 ounces of arsenate of lead per tree, and those dusted with the larger amount received 12.28 ounces of sulfur and 3.07 ounces of arsenate of lead per tree.

DISEASES OF THE SEASON

The weather conditions were very favorable for apple scab (caused by the fungus *Venturia inæqualis*), but the disease did not appear in this orchard. In general the Hudson River section is much freer from this disease than most of western New York, and it is not surprising that no scab developed in this orchard, especially since it has been very thoroughly sprayed a number of times every summer for the past five years.

The persistent rainy weather in July and August favored an unusual development of the sooty blotch disease (caused by the fungus *Phyllacora pomigena*).

INSECTS OF THE SEASON

Owing to thorough spraying in previous years, this orchard was comparatively free from such insects as may be controlled by the use of arsenate of lead, with the exception of the codling moth. Injury by the leaf roller was not serious, only about 5 per cent of the apples being injured by this insect even on the untreated trees. The apples in the untreated plat were injured by the codling moth to a greater extent than in any other orchard treated this season, and therefore a better opportunity was afforded here than elsewhere for determining the relative value of the different mixtures for the control of this insect.

RESULTS OF THE EXPERIMENT

As there was no scab in the orchard, the June drop was not examined. Furthermore, the emergence of codling moth was unusually late, and no apples fell because of injuries by this insect until the week before harvest. The apples were picked and graded on September 28 and 29, and the dropped

⁴ This point is discussed more fully by the writers in Bulletin 354 of this station, page 61.

apples were collected and graded with the picked apples. Except in the untreated plat the dropped apples averaged about one bushel to a tree. Heavy wind of the previous week had caused these apples to fall, and it was found that a high percentage had been attacked by codling moth.

The apples from four trees in each plat were graded. In making the tabulation the apples were first classified into sound and unsound fruit. An apple was regarded as unsound if it had the mark of a disease or an insect that might have been held in check by the treatments



FIG. 70. GRAPHIC REPRESENTATION OF THE PERCENTAGE OF CONTROL OF INSECTS AND DISEASE IN THE VARIOUS PLATS OF THE MITCHELL ORCHARD

U, untreated; S, sprayed; 40-10-50, 1.5, sulfur 40 per cent, lead arsenate 10 per cent, gypsum 50 per cent, 1.5 pounds per tree; 40-10-50, 2, sulfur 40 per cent, lead arsenate 10 per cent, gypsum 50 per cent, 2 pounds per tree; P, perfect; St, stung; C, codling moth; B, blotch

given; thus, apples having very small spots of the sooty blotch disease were classed as imperfect, along with other apples that were so badly blotched as to be unsalable. The unsound apples were further classified, each apple falling under from one to four headings—depending on whether or not it was affected by sooty blotch; whether or not codling moth had attacked it; whether or not leaf roller had attacked it; and whether or not it had been attacked by codling moth or other insects which had died in their early stages, leaving a shallow cavity—a condition commonly referred to by growers as stung. This is a different type of injury from

that recorded in 1914 under the heading *Pinholes*. The pinhole type was rarely observed in 1915.

Most of the "stings" were caused by codling moth caterpillars that either had died soon after eating their way through the skin of the fruit or had soon deserted their burrows and migrated to some other part of the fruit. It is possible that in some cases blemishes caused by some other insect were included under this head, owing to the difficulty of carefully examining these small injuries in the time available when the apples were being graded. Injuries caused by the lesser apple worm were included with those of the codling moth.

Some apples bore marks of more than one form of injury.

The relative value of the various treatments may be seen in figure 70 and table 3. Percentages have been determined, and the means of these percentages, with the probable error⁵ of the means, have been calculated. It is thus possible to take into consideration the numerous casual factors that can be neither controlled nor obviated in such work. The probable error is a measure of the reliability of the experimental results, and the odds are equal that the true result lies somewhere within the range of the figure actually obtained plus or minus the probable error.

Great care has been taken to have the figures in this and succeeding tables accurate. The records in the field were made on counting machines and the transcriptions carefully checked. All computations have been made with mechanical devices, and have been checked independently in the Editorial Office of the College of Agriculture.

SOOTY BLOTCH CONTROL

Sooty blotch became prevalent late in the season, but the spots were not large enough nor prominent enough to greatly mar the appearance of the affected fruits even on the untreated plat. None of the apples from either the sprayed or the dusted plats would have been barred from standard "A" grade because of sooty blotch, while some from the untreated plat were unquestionably too much disfigured to have been admitted to that grade. The percentage of control is somewhat better for the sprayed plat than for the dusted plats. The amount of sulfur applied per tree in both the dusted plats at the last application, the most effective time for preventing this disease, was very low, intentionally so because of general freedom from scab; and considering the difference in adhesion between spray and dust, the slight difference is to be expected.

⁵ Probable error, as developed by Wood and Stratton (Journ. Agr. Sci. 3:434-440. 1910), is equal to $\pm .6745 \sqrt{\frac{\sum d^2}{n(n-1)}}$. In this formula d is the difference between the mean and each individual observation, and n is the number of observations.

TABLE 3. CLASSIFICATION OF BALDWIN APPLES FROM THE MITCHELL ORCHARD

Treatment	Total number of apples	Sound		Unsound		Sooty blotch		Codling moth		Stung		Leaf roller	
		Num-ber	Per-centage	Num-ber	Per-centage	Num-ber	Per-centage	Num-ber	Per-centage	Num-ber	Per-centage	Num-ber	Per-centage
Untreated (Plat 1)	2,352	1,256	55.77	996	44.23	458	20.34	412	18.29	109	4.84	121	5.37
	1,393	656	47.00	737	52.91	341	24.48	344	24.69	73	5.24	87	6.25
	722	412	57.06	310	42.94	98	13.57	182	25.21	28	3.88	36	4.99
	611	252	41.24	359	58.76	46	7.53	299	48.94	10	1.64	29	4.75
Mean	.....	.....	59.29	.....	49.71	.....	16.48	.....	20.28	.....	3.90	.....	5.34
Probable error	.....	.....	±2.52	.....	±2.52	.....	±2.52	.....	±1.54	.....	±0.51	.....	±0.22
Lime-sulfur solution, 2.5 gallons, lead arsenate 2.5 pounds, water to make 100 gallons (Plat 2)	2,250	1,729	76.84	521	23.16	17	0.76	286	12.71	180	8.00	57	2.53
	3,271	2,040	80.71	1,231	37.80	36	1.10	330	10.00	185	5.66	78	2.38
	2,765	2,279	82.42	486	17.58	41	1.48	208	7.52	161	5.82	85	3.07
	1,123	888	79.07	235	20.93	10	0.89	142	12.64	56	4.99	32	2.85
Mean	.....	.....	79.76	.....	20.24	.....	1.06	.....	10.74	.....	6.12	.....	2.71
Probable error	.....	.....	±0.86	.....	±0.86	.....	±0.105	.....	±0.83	.....	±0.44	.....	±0.10
Sulfur 40, lead arsenate 10, gypsum 50 (Plat 3)	1,529	1,264	82.67	265	17.33	66	4.32	87	5.69	74	4.84	43	2.81
	2,419	2,093	86.52	326	13.48	83	3.43	117	4.84	69	2.85	62	2.50
	1,040	852	81.92	188	18.08	31	2.98	68	6.54	45	4.33	50	4.81
	1,069	897	75.49	262	24.51	74	6.92	81	7.58	49	4.58	66	6.17
Mean	.....	.....	81.65	.....	18.35	.....	4.41	.....	6.16	.....	4.15	.....	4.09
Probable error	.....	.....	±1.54	.....	±1.54	.....	±0.61	.....	±0.39	.....	±0.30	.....	±0.58
Sulfur 40, lead arsenate 10, gypsum 50 (Plat 4)	967	809	83.66	158	16.34	26	2.69	54	5.58	38	3.93	46	4.76
	2,284	1,937	84.81	347	15.19	113	4.95	105	4.60	61	2.67	106	2.45
	2,646	2,294	86.70	352	13.30	95	3.59	75	2.83	66	2.49	117	4.42
	1,046	867	82.89	179	17.11	10	0.96	62	5.93	52	4.97	59	5.64
Mean	.....	.....	84.52	.....	15.48	.....	3.05	.....	4.74	.....	3.52	.....	4.32
Probable error	.....	.....	±0.56	.....	±0.56	.....	±0.56	.....	±0.47	.....	±0.39	.....	±0.45

INSECT CONTROL

As shown in the table, more than 29 per cent of the apples on the untreated plat were infested by the codling moth. On the sprayed plat, injury by this insect was reduced to less than 11 per cent, while on the two plats treated with dust the injury was reduced to 6.2 and 4.7 per cent, respectively.

On the untreated plat only 3.9 per cent of the apples were stung, while on the sprayed plat 6.1 per cent, and on the two dusted plats 4.1 and 3.5 per cent, respectively, were injured in this way. The small proportion of stung apples on the untreated plat may be accounted for in part by the fact that in this case a larger proportion of the crop was on the ground, and, these apples being dirty, some of the blemishes were overlooked. In only one of the treated plats were there fewer stung apples than in the untreated plat, and the difference was so slight as to be negligible. From this experiment it would be unsafe to draw any conclusions as to the relative value of the various treatments for the prevention of this injury.

In the untreated plat 5.3 per cent of the apples were injured by leaf roller, while on the sprayed plat only 2.7 per cent, and on the two dusted plats 4.1 and 4.3 per cent, respectively, of the apples were damaged in this way. These figures are of little value, because the first application was made too late to be very effective against this insect. In order to determine the relative value of dusting and spraying for the leaf roller, the material should be applied very soon after the buds begin to open.

EXPERIMENT IN THE ROGERS ORCHARD AT WILLIAMSON

The experimental orchard at Williamson consisted of a block of Maiden Blush trees twelve rows wide and seventeen rows long, with other orchard trees on three sides, as shown in figure 71. The block included an area with space for two hundred and four trees set thirty-three feet apart each way. There are some Baldwin trees mixed in the block, but by chance they did not interfere with the prearranged selection of count trees, except in one case in the untreated plat. The land slopes uniformly to the east. The soil is rich and is well cultivated annually. Thorough spraying is practiced every year. The trees are large, and the branches interlace in many places thus making the work of spraying difficult.

The black lines in the illustration separate variously treated plats, which are designated by arabic numbers in the upper right-hand corners; the letters set in bold-faced type indicate the trees from which counts were made. The location of the untreated plat was decided by the prevailing winds. Observations by the owner and by one of the writers (R) indicate

that in that plat the trees are less subject to apple scab than in almost any other part of the orchard, whereas the trees in plat 5 are most subject to this disease.

	B B B	B B B	B B B	B B B	
X	M M 2	M M 3	M M 4	M M 5	P
X	M M M	M M ¹ M	M M ¹ M	M M M	P
X	M M ¹ M	M M M	M M M	M M M	P
X	M M M	M M M	M M M	M M M	P
X	M M M	M M M	M M M	M M M	P
X	M M ² M	M M ² M	M M ² M	M M M	P
X	M M M	M M M	M M M	M M M	P
X	M M M	M M M	M M M	M M M	P
X	M M ³ M	M M M	M M M	M M M	P
X	M M M	M M M	M M M	M M M	P
X	M M M	M M ³ M	M M ³ M	M M M	P
X	M M ⁴ M	M M M	M M M	M M M	P
X	M M M	M M M	M M M	M M M	P
X	M M 1	M M ⁴ M	M M ⁴ M	M M M	P
X	M ² M ¹ M	M M M	M M M	M M M	P
X	M ³ M ⁴ M	M M M	M M M	M M M	P
X	M M M	M M M	M M M	M M M	P



FIG. 71. PLAN OF EXPERIMENT PERFORMED IN THE ROGERS ORCHARD, WILLIAMSON, NEW YORK

The blocks of trees enclosed in the black lines represent the various plats as indicated by the numbers in the upper right-hand corners. Plat 1, untreated; plat 2, sprayed; plats 3, 4, and 5, dusted with varying proportions of sulfur mixtures. The trees indicated by bold-faced type are the trees from which apples were counted; the exponents refer to the order in which the data are presented in the table. M, Maiden Blush; B, Baldwin; P, pears; X, other varieties of apples

METHODS AND MATERIALS USED

The solution used in the experiment in this orchard was applied with a power spraying outfit having a pressure of 150 pounds or more. Three men and a team were used to operate the sprayer. Two lines of hose were used, two men working from the top of the tank. The dust mixtures were applied with a power outfit operated by a $2\frac{1}{2}$ -horsepower air-cooled engine.

A treatment with scale-strength lime-sulfur solution was given to the entire block at the time when the buds first showed green. Four summer applications were made. The first of these was made when the blossom buds had separated but before the blossoms had opened. The second

was made when only a small proportion of the petals had fallen; the work was done between five and seven o'clock in the morning, and with unusual thoroughness; there was no air stirring, and the dust hung over the orchard in a cloud. The third application was made twenty-one days after the second, and the fourth was made six weeks later. The last application, on July 20, was a little earlier than usual, but this was necessary because of the very late emergence of the first brood of codling moth, and also, and especially, because of the almost continuous rainy weather during the first three weeks in July.

Lime-sulfur solution was used at slightly greater strength, 1-35, than in the other orchards, and paste arsenate of lead, instead of powder, was used in the sprayed plat.

The dusted plats were arranged to test the effectiveness of different quantities of sulfur per tree when applied directly (as nearly as possible twice as much dust being used in one case as in the other, the amount of lead arsenate, however, being kept constant), and to determine whether powdered soap might increase the effectiveness of the mixture. As in the Mitchell orchard, the treatment of all plats was made on the same day, usually in the same forenoon, and no external factors entered to complicate the work.

In table 4 are shown the dates, quantities of material used, and other data, for the different applications. The cost figures are calculated on the same basis as for the Mitchell orchard (page 315). The soap is charged at 9 cents a pound, although soap of the quality used cannot be bought at this figure except in large quantities.

Time lost in making adjustments of various kinds is not included in the record. The time indicated for the sprayed plat is an estimate by Mr. Mason, a member of the company owning the orchard. Time for filling the tank averages fifteen minutes, and as the well is in the center of the orchard practically no time is involved in driving to and from the filling station. The time indicated for spraying, therefore, may be increased one-fourth, in which case the total cost per tree is still somewhat less than the cheapest application of dust.

The table shows also the relative amount of time involved, but the figures require some explanation. The spraying was done about as rapidly as is physically possible. It will be seen that the total time required per tree for spraying was slightly less than two minutes. The average time per tree for dusting in all three plats was slightly more than a half minute (0.514 minute). The average, however, is increased considerably by the necessity of slowing down the team very materially in plats 3 and 5 in order to apply the desired amount of material per tree. In commercial work this would have been overcome by speeding up the engine and by adjusting the outlet to feed more material.

TABLE 4. DATA ON TIME AND METHODS OF APPLICATION, ROGERS ORCHARD, WILLIAMSON, NEW YORK

Date of application	Plat	Num-ber of trees	Material used, and strength	Quan-tity used	Time required						Cost			Cost per tree
					Horse		Man		Machine		Labor	Ma-terial	Total cost	
					Hrs.	Min.	Hrs.	Min.	Hrs.	Min.				
April 30	2	39	Lime-sulfur solution 3	(Gallons)	2	00	3	00	1	00	\$.80	\$1.44	\$2.24	\$.057
May 20	2	39	gallons, lead arsenate	200	2	00	3	00	1	00	.80	1.44	2.24	.057
June 10	2	39	(paste) 4 pounds,	200	2	00	3	00	1	00	.80	1.44	2.24	.057
July 20	2	39	water to make 100	200	2	00	3	00	1	00	.80	1.44	2.24	.057
			gallons											
Total...	...	....	.....	800	8	00	12	00	4	00	\$3.20	\$5.76	\$8.96	\$.228
April 30	4	51	Sulfur 80, lead arsenate	(Pounds)	0	34	0	34	0	17	\$.17	\$4.41	\$4.58	\$.090
May 20	4	51	20	75	0	50	0	50	0	25	.25	3.53	3.78	.074
June 10	4	51		60	0	48	0	48	0	24	.24	4.12	4.36	.085
July 20	4	51		60	0	32	0	32	0	16	.16	3.53	3.69	.072
Total...	...	....	.....	265	2	44	2	44	1	22	\$.82	\$15.59	\$16.41	\$.321
April 30	3	51	Sulfur 90, lead arsenate	(Pounds)	0	56	0	56	0	28	\$.28	\$5.67	\$5.95	\$.117
May 20	3	51	10	130	0	54	0	54	0	27	.27	5.23	5.50	.108
June 10	3	51		120	0	40	0	40	0	20	.20	5.23	5.43	.106
July 20	3	51		140	0	44	0	44	0	22	.22	6.10	6.32	.124
Total...	...	....	.....	510	3	14	3	14	1	37	\$.97	\$22.23	\$23.20	\$.453
April 30	5	51	Sulfur 87.5, lead ar-	(Pounds)	0	50	0	50	0	25	\$.25	\$5.87	\$6.12	\$.120
May 20	5	51	senate 10, powdered	130	1	16	1	16	0	38	.38	7.23	7.61	.149
June 10	5	51	soap 2.5	120	1	00	1	00	0	30	.30	5.60	5.90	.116
July 20	5	51		160	1	18	1	18	0	39	.39	7.23	7.62	.149
Total...	...	....	.....	570	4	21	4	24	2	12	\$1.32	\$25.93	\$27.25	\$.533

At the time of the first application, plat 3 was dusted in fourteen minutes. It was found, however, that only 60 pounds of material had been applied, and the plat was gone over again in exactly the same time and 70 pounds more of the material was distributed. In plat 4 there was no delay because of slow feed from the machine, and the record for this plat may be regarded as more typical of what may be expected under commercial conditions. The average time per tree for an application in this plat was 0.4 minute, or five trees in two minutes.

The relative quantities of the essential ingredients applied per tree are of interest. In the sprayed plat, each tree received on an average in each application 5.78 ounces of sulfur and 1.64 ounces of arsenate of lead. Each tree dusted with the 80-per-cent sulfur dust mixture received in each application an average of 16.62 ounces of sulfur and 4.15 ounces of arsenate of lead. Each tree dusted with the 90-per-cent sulfur dust mixture received in each application an average of 36 ounces of sulfur and 4 ounces of arsenate of lead.

DISEASES OF THE SEASON

The weather conditions of the season were favorable for the development of apple scab. The storm periods in May and June were of sufficient duration to permit abundant primary infection. Little scab developed, however, even in the unsprayed plat, until very late in the season. Two factors tended to suppress scab development: (1) the prolonged dry period in April and early May, which apparently hindered the development of the ascospore stage on the fallen leaves; and (2) the very early spring plowing, which turned under a large proportion of the dead leaves. Following the continuous favorable infection weather after July 1 late infections occurred, but they were not particularly conspicuous until the apples were on the grading table.

INSECTS OF THE SEASON

Leaf-roller caterpillars were present in this orchard in considerable numbers, as indicated by the percentage of injured apples on the untreated trees — 10.67 per cent. Bud moth was about as abundant as is usual in orchards receiving good care. Codling moth was less in evidence in this orchard than in any other orchard treated this season.

RESULTS OF THE EXPERIMENT

The few apples on the ground at picking time were examined, but as they did not seem to be affected to any greater degree than those from the trees they were not included in the count. As may be seen from table 5, the only results of consequence are in the control of scab. Apples on the check plat did not develop as high a percentage of scab as was desirable for

TABLE 5. CLASSIFICATION OF MAIDEN BLUSH APPLES FROM THE ROGERS ORCHARD

Treatment	Total number of apples	Sound		Unsound		Apple scab		Codling moth		Stung		Leaf roller		Bud moth	
		Num-ber	Per-centage	Num-ber	Per-centage	Num-ber	Per-centage	Num-ber	Per-centage	Num-ber	Per-centage	Num-ber	Per-centage	Num-ber	Per-centage
Untreated (Plat 1)	1,799	1,125	62.53	674	37.47	425	23.62	11	0.61	43	2.39	174	9.67	21	1.17
	1,902	1,075	56.49	827	43.51	502	26.39	23	1.17	115	5.86	109	10.14	48	2.45
	3,006	1,822	60.61	1,184	39.39	935	21.12	31	1.03	114	3.76	368	12.24	36	1.20
	3,059	2,388	78.06	671	21.94	660	10.50	19	0.52	204	5.58	390	10.60	52	1.42
Mean	.....	.....	60.80	.....	39.20	.....	21.72	.....	0.83	.....	4.41	.....	10.68	.....	1.56
Probable error	.....	.....	±1.50	.....	±1.50	.....	±1.27	.....	±0.11	.....	±0.55	.....	±0.38	.....	±0.20
Lime-sulfur solution 3 gallons, lead arsenate (paste) 4 pounds, water to make 100 gallons (Plat 2)	2,227	1,870	83.97	357	16.03	13	0.58	7	0.31	93	4.18	205	9.21	58	2.60
	1,539	1,271	82.59	268	17.41	8	0.52	.....	.....	45	2.92	195	12.67	20	1.30
	1,434	1,158	80.75	276	19.25	18	1.26	4	0.28	69	4.81	173	12.06	12	0.84
	3,331	2,770	83.16	561	16.84	51	1.53	2	0.06	107	3.21	358	10.75	43	1.29
Mean	.....	.....	82.62	.....	17.38	.....	0.97	.....	0.16	.....	3.78	.....	11.17	.....	1.51
Probable error	.....	.....	±0.46	.....	±0.46	.....	±0.17	.....	±0.04	.....	±0.29	.....	±0.52	.....	±0.26
Sulfur 80, lead arsenate 20 (Plat 4)	1,260	1,062	84.29	198	15.71	27	2.14	.....	.....	37	2.94	125	9.92	9	0.71
	1,089	1,750	87.98	239	12.02	32	1.61	.....	.....	20	1.01	180	9.05	10	0.50
	1,448	1,200	82.87	248	17.13	11	0.76	.....	.....	27	1.86	205	14.16	6	0.41
	1,576	1,307	82.93	269	17.07	17	1.08	.....	.....	44	2.79	194	12.31	9	0.57
Mean	.....	.....	84.52	.....	15.48	.....	1.40	.....	.....	.....	2.15	.....	11.36	.....	0.55
Probable error	.....	.....	±0.81	.....	±0.81	.....	±0.20	.....	.....	.....	±0.30	.....	±0.77	.....	±0.43
Sulfur 90, lead arsenate 10 (Plat 3)	2,210	1,859	84.12	351	15.88	31	1.40	1	0.05	59	2.67	234	10.59	26	1.18
	2,190	1,903	86.89	287	13.11	20	0.91	3	0.14	38	1.74	180	9.77	12	0.55
	2,997	1,997	83.31	400	16.69	20	0.83	.....	.....	37	1.54	338	14.10	5	0.21
	1,998	1,739	87.04	259	12.96	45	2.25	.....	.....	40	2.00	161	8.06	13	0.65
Mean	.....	.....	85.34	.....	14.66	.....	1.35	.....	0.05	.....	1.99	.....	10.63	.....	0.65
Probable error	.....	.....	±0.64	.....	±0.64	.....	±0.22	.....	±0.01	.....	±0.17	.....	±0.85	.....	±0.14

the purposes of the experiment. The control with spray and with dust was all that could be desired (Fig. 72). The figures as shown in the table do not fully indicate the difference between the various plats, for in many cases the spots of scab on the fruit in the treated plats were exceedingly small and in some cases there was apparent only the small red spot that precedes the appearance of scab on this variety. Mr. Rogers stated that only once before in his memory had this Maiden Blush orchard been so free from scab as it was this year.



FIG. 72. GRAPHIC REPRESENTATION OF THE PERCENTAGE OF CONTROL OF INSECTS AND DISEASE IN THE VARIOUS PLATS OF THE ROGERS ORCHARD

U, untreated; S, sprayed; 80-20, sulfur 80 per cent, lead arsenate 20 per cent; 90-10, sulfur 90 per cent, lead arsenate 10 per cent; P, perfect; St, stung; C, codling moth; Sc, scab

The table indicates a slight reduction for the treated plats in the amount of fruit classed as stung, and a similar slight reduction for the dusted plats in the infestation by the August brood of bud moth. Codling moth injury, aside from that classed as stung, was practically absent, and the eighty-four apples attacked in the untreated plat were all entered from the side.

EXPERIMENT IN THE JUNGBLUTH ORCHARD AT SPENCERPORT

The experimental orchard at Spencerport consisted of a block of Twenty Ounce trees twelve rows wide by nineteen rows long, with apple trees of

another variety on one side only as shown in figure 73. The block included an area with space for two hundred and twenty-eight trees set forty feet apart each way. The trees were thirty-five years old. At the age of fifteen years Baldwin trees were top-worked to Twenty Ounce, and, due to the natural high-growing tendency of the variety Twenty Ounce, the trees were at the time of the experiment very tall for their age. Some of the trees had reverted to Baldwin because of injury to the grafts from New York apple tree canker (*Physalospora Cydoniae* Arnaud), but these were largely on the west side of the orchard, where the set of fruit this year

X X X X X X X X X X X																			
T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	5
T	T	T	T	T	T	T	T	T	T	T⁴	T	T³	T	T²	T	T	T¹	T	T
T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	4
T	T	T	T	T	T	T	T	T	T	T⁴	T	T³	T	T²	T	T	T¹	T	T
T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	3
T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
T	T	T	T	T	T	T	T	T	T	T⁴	T	T³	T	T²	T	T	T¹	T	T
T	T	T	T	T	T	T	T	T	T	T⁴	T³	T²	T	2	T	T	T	1	
T	T	T	T	T	T	T	T	T	T	T	T	T	T	T¹	T	T²	T¹	T	
T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T³	T⁴	T	

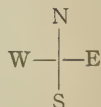


FIG. 73. PLAN OF EXPERIMENT PERFORMED IN THE JUNGLUTH ORCHARD, SPENCERPORT, NEW YORK

The blocks of trees enclosed in the black lines represent the various plats as indicated by the numbers in the upper right-hand corners. Plat 1, untreated; plat 2, sprayed; plats 3, 4, and 5, dusted with varying proportions of sulfur mixtures. The trees indicated by bold-faced type are the trees from which apples were counted; the exponents refer to the order in which the data are presented in the table. T, Twenty Ounce; X, Gravenstein

was practically ruined by the late frost. The land is nearly level, and the soil, which is a stony loam, is well cultivated each spring and is seeded to a cover crop in July.

The black lines in the illustration separate the variously treated plats, which are designated by arabic numerals in the upper right-hand corners; the letters set in bold-faced type indicate the trees from which counts were made.

A prearranged selection of count trees was followed except in the sprayed area (plat 2), where the set of fruit was very irregular and was light on all trees.

The check plat was unfortunately situated. It was originally located on the west side of the orchard, but was changed because of the large number of reverted trees there. As finally located, the plat was too near a dusted plat, and in the path of the prevailing wind. Even on days when very little wind was stirring, an occasional breeze would carry a quantity of dust across the check plat. It so happened that in every application some dust was distributed on the "untreated" plat, and at the time of the first application a considerable quantity lodged there.

METHODS AND MATERIALS USED

The solution used in the experiment in this orchard was applied with a power spraying outfit. Three men and a team were used to operate the sprayer. Two lines of hose were used, and one man sprayed from a high tower and another from the ground. The dust mixtures were applied with a new dusting machine operated by a $2\frac{1}{2}$ -horsepower air-cooled engine. The engine did not develop its full capacity, and the new duster ran heavily, so that it was possible to reach the tops of the trees only by lengthening the outlet pipe. This was not a disadvantage, however, since there were few low branches to interfere.

Scale-strength lime-sulfur was applied to all the trees while in the dormant condition, and all the trees were sprayed with a commercial carbolated soap preparation when the first leaves had unfolded but the blossom clusters had not yet separated. This treatment resulted in severe injury to foliage and to blossom buds. Four summer applications were made: the first when the blossom clusters had entirely separated, the second when most of the petals had fallen, the third three weeks after the second, and the fourth nine weeks after the second. All the dusted plats were treated on the same day, but it may be seen from table 6 that in some cases the spraying was not done until a day or two later. These differences in date of application would assuredly have made a difference in the amount of scab, had that disease developed in the orchard. They may give a slight advantage to the degree of insect control in the sprayed plat, due to the fact that the poison was applied after a period of rain instead of before, and as a result a certain amount of poison remained that might have been washed away. Apparently the washing away of lead arsenate is much less than has generally been supposed.

The dusted plats were arranged to test the effectiveness of different quantities of sulfur per tree, both by the direct method and by the use of a diluent — in this case hydrated lime. A marked difference was noted in the flowing qualities of the three mixtures. The 80-20 mixture flowed very freely, the 90-10 mixture was much more sluggish, and the mixture containing lime as a diluent could not be forced through the duster in the quantity desired.

In the sprayed plat powdered lead arsenate was used at slightly greater strength than in the other orchards.

The dates of application, the quantities of material used, and other data for this orchard, are given in table 6. The cost figures are calculated on the same basis as for the Mitchell orchard (page 315). The hydrated lime is charged at 40 cents a hundredweight, although small quantities probably cannot be bought at this price.

Time lost in making adjustments of various kinds is not included in the record. The time indicated for the sprayed plat is partly an estimate, but in all cases the time required for filling the tank and for driving to and from the orchard is included. This must be kept in mind in comparing this table with previous ones. It is evident that the total cost per tree for spraying was greater than for dusting with two of the mixtures used. It may be noted also that the average time per tree to make an application of the spray mixture in this orchard was 2.86 minutes, whereas the average time for making an application of dust was 0.36 minute per tree. In plat 3, where the application was made without slowing the team (but where an open ditch obstructed the way in making one turn), the average time per tree for one application was 0.311 minute, or more than three trees a minute.

In this orchard the relative quantities of essential ingredients for each application are as follows: in the sprayed plat each tree received on an average practically 6 ounces of sulfur and 3.06 ounces of arsenate of lead; in the plat dusted with the mixture containing 80 per cent of sulfur, each tree received an average of 18.24 ounces of sulfur and 4.56 ounces of arsenate of lead; in the plat dusted with the mixture containing 90 per cent of sulfur, each tree received an average of 31.58 ounces of sulfur and 3.5 ounces of arsenate of lead; in the plat dusted with the mixture containing hydrated lime, each tree received an average of 11.23 ounces of sulfur and 2.8 ounces of arsenate of lead.

DISEASES OF THE SEASON

Weather conditions were exceedingly favorable for the development of the scab disease, but, as in the Rogers orchard, dry weather through April and early spring plowing served to reduce primary infection very materially. The sulfur that drifted to the check plat may have prevented the development of secondary infections; judging by conditions in neighboring orchards, this would seem to have been the case.

INSECTS OF THE SEASON

Leaf roller was abundant enough to injure 15.77 per cent of the apples on the untreated plat and a much larger proportion on the treated plats.

TABLE 6. DATA ON TIME AND METHODS OF APPLICATION, JUNGBLUTH ORCHARD, SPENCERPORT, NEW YORK

Date of applica- tion	Plat	Num- ber of trees	Material used, and strength	Quan- tity used	Time required				Cost					
					Horse		Man		Machine	Labor	Ma- terial	Total cost		
					Hrs.	Min.	Hrs.	Min.					Hrs.	Min.
May 1	2	55	Lime-sulfur solution 2.5	(Gallons)	6	00	9	00	3	00	\$2.40	\$2.94	\$5.34	\$.097
May 19	2	55	gallons, lead arsenate	400	5	00	7	30	2	30	2.00	3.36	5.36	.097
June 12	2	55	3 pounds, water to	350	5	00	7	30	2	30	2.00	2.94	4.94	.090
July 20	2	55	make 100 gallons	300	5	00	7	30	2	30	2.00	2.52	4.52	.082
Total...	...	...	.....	1,400	21	00	31	30	10	30	\$8.40	\$11.76	\$20.16	\$.366
April 30	4	57	Sulfur 80, lead arsenate	(Pounds)	0	40	0	40	0	20	\$.20	\$4.70	\$4.90	\$.086
May 19	4	57	20	90	0	34	0	34	0	17	.17	5.29	5.46	.096
June 10	4	57		75	0	34	0	34	0	17	.17	4.41	4.58	.080
July 20	4	57		80	0	34	0	34	0	17	.17	4.70	4.87	.085
Total...	...	...	.....	325	2	22	2	22	1	11	\$.71	\$19.10	\$19.81	\$.347
April 30	3	57	Sulfur 90, lead arsenate	(Pounds)	0	38	0	38	0	19	\$.19	\$5.24	\$5.43	\$.095
May 19	3	57	10	160	0	56	0	56	0	28	.28	6.99	7.27	.128
June 10	3	57		100	0	44	0	44	0	22	.22	4.37	4.59	.081
July 20	3	57		120	0	44	0	44	0	22	.22	5.24	5.46	.096
Total...	...	...	.....	500	3	02	3	02	1	31	\$.91	\$21.84	\$22.75	\$.400
April 30	5	57	Sulfur 40, lead arsenate	(Pounds)	0	38	0	38	0	19	\$.19	\$3.14	\$3.33	\$.058
May 19	5	57	10, hydrated lime 50	120	0	54	0	54	0	27	.27	3.77	4.04	.071
June 10	5	57		100	0	42	0	42	0	21	.21	3.14	3.35	.059
July 20	5	57		80	0	38	0	38	0	19	.19	2.51	2.70	.047
Total...	...	...	.....	400	2	52	2	52	1	26	\$.86	\$12.56	\$13.42	\$.235

Many of the apples were entirely destroyed while small, and the figures given in the tables do not show the total loss caused by this insect, which caused more injury in this orchard than any other insect with the possible exception of the rosy aphid. As is usual where the crop is small, the proportion of apples injured by the codling moth is high — 16.18 per cent on the untreated trees. In addition to this, about 25 per cent of the apples showed the scars made by young codling moth larvæ that deserted their burrows soon after entering the fruit. These apples are classed as stung.

RESULTS OF THE EXPERIMENT

DISEASE CONTROL

As may be seen from table 7, too little scab developed in the check plot to make the record of any value in regard to the control of that disease.

INSECT CONTROL

The proportion of apples injured by codling moth was fairly high in the untreated plot. In most of the apples injured the insects entered at the side of the fruit. The amount of injury was also considerable in the sprayed plot and in the plot treated with the 90-per-cent dust mixture. It may be noted that the probable error for these plots is large, and also that in general the individual trees showing a high percentage of injury had a very low yield. The quantity of poison applied in plot 5 was not so great as was applied in plot 3, and it is probable that the percentage of control indicated in either plot 4 or plot 5 represents more nearly the degree of control effected. All the trees in the sprayed plot had small yields, and the percentage of infestation indicated is doubtless too high for normal conditions.

It will be noted that about 25 per cent of the apples on the untreated plot were stung. On the sprayed plot this type of injury was reduced to 21.7 per cent. On the plot that received dust containing 20 per cent of lead arsenate the injury was reduced to 13.86 per cent, while in the plot treated with dust containing 90 per cent of sulfur the injury was reduced only to 18.98 per cent. In the plot on which lime was used as a diluent the injury was reduced to 15.6 per cent. These results are about what might be expected on the basis of other experiments, but too much reliance should not be placed on them in view of the facts previously stated.

In regard to leaf roller, the table shows that there was less injury by this insect on the untreated plot than on any of the treated plots. This is doubtless due to mere chance. In any case the first application of poison was made too late to be effective against the leaf roller, and it would be unsafe to draw any conclusions from the experiment as to the relative value of the mixtures.

TABLE 7. CLASSIFICATION OF TWENTY OUNCE APPLES FROM THE JUNGBLUTH ORCHARD

Treatment	Total number of apples	Sound		Unsound		Apple scab		Codling moth		Stung		Leaf roller	
		Num-ber	Per-centage	Num-ber	Per-centage	Num-ber	Per-centage	Num-ber	Per-centage	Num-ber	Per-centage	Num-ber	Per-centage
Untreated (Plat 1)	883	523	59.23	360	40.77	26	2.94	74	8.38	227	25.71	102	11.55
	611	306	50.08	305	49.92	10	1.64	103	16.86	76	12.44	90	14.73
	305	127	41.64	178	58.36	13	4.26	80	26.23	82	26.89	51	16.72
	234	104	44.44	130	55.56	6	2.56	31	13.25	82	35.04	47	20.09
Mean.....	.....	.....	48.85	.....	51.15	.....	2.85	.....	16.18	.....	25.02	.....	15.77
Probable error.....	.....	.....	±2.62	.....	±1.62	.....	±0.37	.....	±2.55	.....	±3.16	.....	±1.21
Lime-sulfur solution 2.5 gallons, lead arsenate 3 pounds, water to make 100 gallons (Plat 2)	216	132	61.11	84	38.89	1	0.46	10	4.63	51	23.61	30	13.89
	308	150	48.70	158	51.30	.....	.....	30	9.74	62	20.13	95	30.84
	229	120	52.40	109	47.60	.....	.....	22	9.61	49	21.40	75	32.75
	392	196	50.00	196	50.00	1	0.26	29	7.40	85	21.68	104	26.53
Mean.....	.....	.....	53.05	.....	46.95	.....	0.18	.....	7.85	.....	21.71	.....	26.00
Probable error.....	.....	.....	±1.88	.....	±1.88	.....	±0.06	.....	0.81	.....	0.48	.....	2.86
Sulfur 80, lead arsenate 20 (Plat 4)	783	481	61.43	302	38.57	4	0.51	24	3.07	130	16.60	181	23.12
	790	511	64.68	279	35.32	9	1.14	21	2.53	101	12.78	177	22.41
	907	621	68.47	286	31.53	0	0.99	20	2.32	89	9.81	182	20.07
	732	456	62.30	276	37.70	3	0.41	16	2.19	119	16.26	159	21.72
Mean.....	.....	.....	64.22	.....	35.78	.....	0.76	.....	2.53	.....	13.86	.....	21.83
Probable error.....	.....	.....	±1.06	.....	±1.06	.....	±0.12	.....	±0.13	.....	±1.09	.....	±0.44
Sulfur 90, lead arsenate 10 (Plat 3)	1,052	748	71.10	304	28.90	4	0.38	28	2.66	126	11.98	156	14.83
	721	438	60.75	283	39.25	1	0.14	32	4.44	132	18.31	147	20.39
	432	245	56.71	187	43.29	2	0.46	38	8.80	66	15.28	98	22.60
	389	162	41.65	227	58.35	4	1.03	49	12.60	118	30.33	91	23.39
Mean.....	.....	.....	57.55	.....	42.45	.....	0.50	.....	7.13	.....	18.98	.....	20.33
Probable error.....	.....	.....	±4.12	.....	±4.12	.....	±0.13	.....	±1.51	.....	±2.70	.....	±1.31
Sulfur 40, lead arsenate 10, hydrated lime 50 (Plat 5)	978	608	71.37	280	28.63	11	1.12	27	2.76	118	12.07	141	14.42
	701	450	64.19	251	35.81	2	0.29	25	3.57	123	17.55	133	18.97
	881	612	72.87	239	27.13	2	0.23	18	2.04	112	12.71	128	14.53
	831	505	60.77	326	39.23	6	0.72	36	4.33	167	20.10	174	20.94
Mean.....	.....	.....	67.30	.....	32.70	.....	0.59	.....	3.18	.....	15.61	.....	17.22
Probable error.....	.....	.....	±1.94	.....	±1.94	.....	±0.14	.....	±0.33	.....	±1.30	.....	±1.10

EXPERIMENTS IN THE GLIDDEN ORCHARD AT HOLLEY

The experimental orchard at Holley consisted of a block of Baldwin and one of Rhode Island Greening trees, with some Roxbury trees in the Rhode Island Greening block. The area is not perfectly regular, as may be seen from figure 74. It comprises about thirteen acres, with space for three hundred and fifty-eight trees set about forty feet apart each way. The trees are over fifty years old; they are very large, and some of them, particularly the Rhode Island Greenings, have a very great spread. The land is nearly level. The soil is a good clay loam and is tilled every other year. This year the orchard was plowed fairly early and was cultivated until about August 1, when a cover crop of rye was sown.

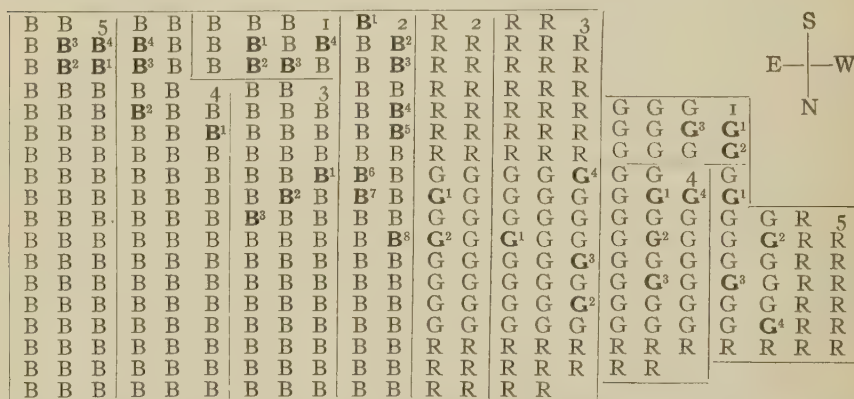


FIG. 74. PLAN OF EXPERIMENTS PERFORMED IN THE GLIDDEN ORCHARD, HOLLEY, NEW YORK

The blocks of trees enclosed in the black lines represent the various plats as indicated by the numbers in the upper right-hand corners. Plat 1, untreated; plat 2, sprayed; plats 3, 4, and 5, dusted with varying proportions of sulfur mixtures. The trees indicated by bold-faced type are the trees from which apples were counted; the exponents refer to the order in which the data are presented in the table. B, Baldwin; G, Rhode Island Greening; R, Roxbury Russet

The black lines in the illustration separate the variously treated plats, which are designated by arabic numerals in the upper right-hand corners; the letters set in bold-faced type indicate the trees from which the apples were counted.

The prospects for a crop of Baldwin apples were only fair, but the prospects for Rhode Island Greenings were never better. Cold weather, however, reduced the set of the fruit so much that the experiment was nearly ruined. The trees in the sprayed plats suffered severely, and it is doubtful whether the figures for that plat can be accepted.

Curiously enough, the Rhode Island Greening trees in the untreated plat bore the largest amount of fruit of any of the trees. Two trees had heavy crops, but as these are pointed out by the owners and by neighbors

as trees on which scab usually occurs they were not included in the count trees from plat 1. The selection of count trees in the other plats depended entirely on whether there were enough apples left to give a fair representation of the plat, or whether there were any apples at all in the plat.

METHODS AND MATERIALS USED

The equipment for spraying and dusting, a power spraying outfit and a dusting machine with a $2\frac{1}{2}$ -horsepower engine, was the same as was used in the 1914 experiment in another part of the same orchard.

A treatment of scale-strength lime-sulfur solution was given in this orchard at the time when the buds were showing green. The summer treatments were planned to compare spraying with dusting, and to test the effectiveness of different quantities of sulfur. In one case a reduced quantity of sulfur was applied; in the other case nearly double the quantity of material was applied, but gypsum (*terra alba*) was used as a diluent. Four summer applications were made. The first was made when the blossom buds had separated in the cluster. This treatment was given on May 1, following a gentle rain that had fallen through most of the afternoon and night of April 30. It is believed that this application forestalled most of the actual scab infection. The second application was made when the Rhode Island Greening trees were literally white with blossoms and before all the petals had fallen from the Baldwin trees. This application was necessary because of threatening rainy weather and the fact that nineteen days had intervened since the first application. The third application was made three weeks after the second, and the fourth application nine weeks after the second.

The treatments of the various plats were made on the same day in every case, and no outside influence entered to interfere with the outcome of the experiments. The applications were made without incident. There was no breakage, and no time lost for adjustment. This is taken as an indication of what may be expected from experience with the dust method. In 1915 the average time per tree for making an application of dust was 0.618 minute; in 1914 it was 0.878 minute. Although time was taken out for adjustments, the difference of 0.26 minute per tree is to be credited chiefly to experience, since the trees were only one year older and were of the same size, and on the whole they were less accessible in the 1915 work than in 1914.

As may be seen from table 8, the average time required for spraying was 2.64 minutes. This is somewhat more than four times as long as is required for dusting, and the record does not include time for filling the tank or for driving to and from the orchard.

TABLE 8. DATA ON TIME AND METHODS OF APPLICATION, GLIDDEN ORCHARD, HOLLEY, NEW YORK

Date of applica- tion	Plat	Num- ber of trees	Material used, and strength	Quan- tity used	Time required						Cost			Cost per tree
					Horse		Man		Machine		Labor	Ma- terial	Total cost	
					Hrs.	Min.	Hrs.	Min.	Hrs.	Min.				
May 1	2	72	Lime-sulfur solution 2.5	(Gallons)	6	20	6	20	3	10	\$1.90	\$3.00	\$4.90	\$.068
May 20	2	72	gallons, lead arsenate	400	6	20	6	20	3	10	1.90	3.00	4.90	.068
June 11	2	72	2.5 pounds, water to	425	6	12	6	12	3	06	1.86	3.19	5.05	.070
July 21	2	72	make 100 gallons	400	6	30	6	30	3	15	1.95	3.00	4.95	.069
Total..	...	....	.....	1,225	25	22	25	22	12	41	\$7.61	\$12.19	\$19.80	\$.275
May 1	4B	51	Sulfur 80, lead arsenate	(Pounds)	0	52	0	52	0	26	\$.26	\$4.70	\$4.96	\$.097
May 20	4B	51	20	100	1	14	1	14	0	37	.37	5.88	6.25	.123
June 11	4B	51		80	0	56	0	56	0	28	.28	4.70	4.98	.098
July 21	4B	51		80	0	54	0	54	0	27	.27	4.70	4.97	.097
Total..	...	....	.....	340	3	56	3	56	1	58	\$1.18	\$19.98	\$21.16	\$.415
May 1	4G	29	Sulfur 80, lead arsenate	(Pounds)	0	38	0	38	0	19	\$.19	\$3.82	\$4.01	\$.138
May 20	4G	29	20	65	1	10	1	10	0	35	.35	7.64	7.99	.276
June 11	4G	29		70	0	38	0	38	0	19	.19	4.12	4.31	.149
July 21	4G	29		60	0	34	0	34	0	17	.17	3.53	3.70	.127
Total..	...	....	.....	325	3	00	3	00	1	30	\$.90	\$19.11	\$20.01	\$.690
May 1	3B	45	Sulfur 90, lead arsenate	(Pounds)	0	52	0	52	0	26	\$.26	\$5.24	\$5.50	\$.122
May 20	3B	45	10	120	1	00	1	00	0	30	.30	6.98	7.28	.162
June 11	3B	45		140	0	48	0	48	0	24	.24	6.11	6.35	.141
July 21	3B	45		100	0	46	0	46	0	23	.23	4.37	4.60	.102
Total..	...	....	.....	520	3	26	3	26	1	43	\$1.03	\$22.70	\$23.73	\$.527

TABLE 8 (concluded)

Date of application	Plat	Num-ber of trees	Material used, and strength	Quan-tity used	Time required						Cost			Cost per tree
					Horse		Man		Machine		Labor	Ma-terial	Total cost	
					Hrs.	Min.	Hrs.	Min.	Hrs.	Min.				
May 1	3G	53	Sulfur 90, lead arsenate	(Pounds)	0	56	0	56	0	28	\$.28	\$6.55	\$6.83	\$.129
May 20	3G	53	10	150	1	18	1	18	0	39	.39	6.98	7.37	.139
June 11	3G	53		160	0	58	0	58	0	29	.29	6.98	7.27	.137
July 21	3G	53		120	1	04	1	04	0	32	.32	5.24	5.56	.105
Total..	...	....	.....	590	4	16	4	16	2	08	\$1.28	\$25.75	\$27.03	\$.510
May 1	5B	54	Sulfur 40, lead arsenate	(Pounds)	1	02	1	02	0	31	\$.31	\$3.77	\$4.08	\$.076
May 20	5B	54	10, gypsum 50	120	1	14	1	14	0	37	.37	3.77	4.14	.077
June 11	5B	54		130	1	10	1	10	0	35	.35	4.08	4.43	.082
July 21	5B	54		100	1	02	1	02	0	31	.31	3.14	3.45	.064
Total..	...	....	.....	470	4	28	4	28	2	14	\$1.34	\$14.76	\$16.10	\$.299
May 1	5G	30	Sulfur 40, lead arsenate	(Pounds)	0	34	0	34	0	17	\$.17	\$2.51	\$2.68	\$.089
May 20	5G	30	10, gypsum 50	80	0	50	0	50	0	25	.25	2.51	2.76	.092
June 11	5G	30		120	0	36	0	36	0	18	.18	3.77	3.95	.132
July 21	5G	30		80	0	30	0	30	0	15	.15	2.51	2.66	.089
Total..	...	....	.....	360	2	30	2	30	1	15	\$.75	\$11.30	\$12.05	\$.402

In this orchard the relative quantities of essential ingredients per tree for each application are as follows: in the sprayed plat, an average of 4 ounces of sulfur and 1.7 ounces of arsenate of lead; in the plats dusted with the 80-20 mixture, 26.73 ounces of sulfur and 6.73 ounces of lead arsenate; in the plats treated with the 90-10 mixture, 40.76 ounces of sulfur and 4.27 ounces of lead arsenate; in the plats treated with the mixture containing gypsum, 15.33 ounces of sulfur and 4 ounces of lead arsenate. The trees in the sprayed plat did not receive as much liquid per tree as did the trees of similar size and of the same age in the experiment of 1914. As a result the quantities of the essential ingredients are very low in this plat.

DISEASES OF THE SEASON

At the time of the second application in this orchard, on May 20, the foliage was free from disease so far as could be seen, but at the time of the third application, on June 11, the scab disease was abundant on the foliage and common on the fruit of the untreated Rhode Island Greening trees. The fourth application was made a little earlier than usual (on July 21), because of the exceedingly favorable weather for the spread of apple scab. These conditions continued throughout the remainder of July and through August, making possible the further spread of the apple scab fungus; so that at the time of harvesting the Rhode Island Greenings, September 20 and 21, small spots of late infection were appearing, and at the time of harvesting the Baldwins, October 15 and 16, such spots were numerous. The same conditions were favorable for the abundant development of sooty blotch (caused by the fungus *Phyllacora pomigena*).

INSECTS OF THE SEASON

Codling moth was not very abundant in this orchard. The insect was late in emerging and the emergence extended over a long period. Most of the caterpillars entered at the side of the fruit. There was a fairly even, but slight, infestation of leaf roller. Other insects were present only in very small numbers.

RESULTS OF THE EXPERIMENT ON RHODE ISLAND GREENING APPLES

DISEASE CONTROL

As may be seen from table 9 and figure 75, both the scab disease and the sooty blotch were very abundant on the untreated plat of Rhode Island Greenings and were held in control by all the treatments. Unfortunately a comparison of sprayed and dusted plats cannot be made in fairness, because of the exceedingly poor yield of fruit on the sprayed trees. The yield indicated in the table, approximately one barrel, is the total yield of the twenty sprayed trees, except for scattered apples on trees here and

TABLE 9. CLASSIFICATION OF RHODE ISLAND GREENING APPLES FROM THE GLIDDEN ORCHARD

Treatment	Total number of apples	Sound		Unsound		Apple scab		Sooty blotch		Codling moth		Stung		Leaf roller	
		Num-ber	Per-centage	Num-ber	Per-centage	Num-ber	Per-centage	Num-ber	Per-centage	Num-ber	Per-centage	Num-ber	Per-centage	Num-ber	Per-centage
Untreated (Plat 1)	1,754	36	2.05	1,718	97.95	1,586	90.42	897	51.14	139	7.02	445	25.37	232	13.23
	1,504	143	9.51	1,361	90.49	1,130	75.13	379	25.20	41	2.73	310	20.61	100	12.63
	359	63	11.27	496	88.73	379	67.80	66	11.81	68	12.10	159	28.44	75	13.42
Mean.	.....	.....	7.61	.....	77.78	.....	27.38	.....	27.38	.....	7.60	.....	24.81	.....	13.09
Probable error.....	.....	.....	±1.90	.....	±4.49	.....	±7.78	.....	±7.78	.....	±1.84	.....	±1.54	.....	±0.16
Lime-sulfur solution 2.5 gallons, lead arsenate 2.5 pounds, water to make 100 gallons (Plat 2)	127	91	71.65	36	28.35	.....	.....	1	0.79	3	2.36	19	14.96	14	11.02
	203	163	80.30	40	19.70	1	0.49	1	0.49	2	0.99	11	5.42	30	14.78
Mean.	.....	.....	75.98	.....	24.02	.....	0.25	.....	0.64	.....	1.68	.....	10.19	.....	12.90
Probable error.....	.....	.....	±2.92	.....	±2.92	.....	±0.17	.....	±0.16	.....	±0.46	.....	±3.22	.....	±1.27
Sulfur 80, lead arsenate 20 (Plat 4)	788	537	68.15	251	31.85	73	9.26	32	4.06	8	1.02	60	7.61	114	14.47
	319	210	65.83	109	34.17	32	10.03	17	5.33	1	0.31	52	16.30	50	17.55
	121	56	46.28	65	53.72	7	5.79	5	4.13	8	6.51	26	21.49	28	23.14
	881	509	57.78	372	42.22	106	12.03	15	1.70	20	2.27	118	13.39	172	19.52
Mean.	.....	.....	59.51	.....	40.49	.....	9.28	.....	3.81	.....	2.55	.....	14.70	.....	18.67
Probable error.....	.....	.....	±3.33	.....	±3.33	.....	±0.88	.....	±0.51	.....	±0.95	.....	±2.10	.....	±1.23
Sulfur 90, lead arsenate 10 (Plat 3)	272	202	74.26	70	25.74	7	2.57	4	1.47	6	2.21	18	6.62	41	15.07
	233	145	62.23	88	37.77	24	10.30	13	5.58	1	0.43	21	9.01	47	20.17
	118	79	66.95	39	33.05	12	10.17	7	5.93	.....	.....	16	13.56	12	10.17
	98	67	68.37	31	31.63	4	4.08	15	15.31	1	1.02	10	10.20	8	8.16
Mean.	.....	.....	67.95	.....	32.05	.....	6.78	.....	7.07	.....	0.92	.....	9.85	.....	13.39
Probable error.....	.....	.....	±1.67	.....	±1.67	.....	±1.36	.....	±1.97	.....	±0.32	.....	±0.97	.....	±1.81
Sulfur 40, lead arsenate 10, gypsum 50 (Plat 5)	423	270	63.83	153	36.17	49	11.58	14	3.31	4	0.95	39	9.22	66	15.00
	657	463	70.47	194	29.53	34	5.18	7	1.07	14	2.13	69	10.50	94	14.31
	434	274	63.13	160	36.87	18	4.15	2	0.46	11	2.53	72	16.59	86	19.82
	318	202	63.52	116	36.48	17	5.35	2	0.63	8	2.52	40	12.58	59	18.55
Mean.	.....	.....	65.24	.....	34.76	.....	6.57	.....	1.37	.....	2.03	.....	12.22	.....	17.07
Probable error.....	.....	.....	±1.18	.....	±1.18	.....	±1.14	.....	±0.44	.....	±0.25	.....	±1.09	.....	±0.86

there. The amount of scab or blotch on all treated trees was small, and in most cases the spots were so small that the fruit could be classed as New York standard "A" grade.

The test on the amount of sulfur required per tree, when judged by the control of scab, would indicate that the reduced amount is entirely effective (as seen in plat 5, dusted with the mixture containing gypsum), but that better distribution can be brought about by the use of a diluent (as seen in plat 4, dusted with the 80-20 mixture). It is not clear, how-



FIG. 75. GRAPHIC REPRESENTATION OF THE PERCENTAGE OF CONTROL OF INSECTS AND DISEASES IN THE VARIOUS PLATS OF THE GLIDDEN RHODE ISLAND GREENING ORCHARD

U, untreated; S, sprayed; 80-20, sulfur 80 per cent, lead arsenate 20 per cent; 90-10, sulfur 90 per cent, lead arsenate 10 per cent; 40-10-50, sulfur 40 per cent, lead arsenate 10 per cent, gypsum 50 per cent; P, perfect; St, stung; C, codling moth; Sc, scab; B, blotch

ever, why the percentage of sooty blotch should have been higher in plat 3, which received the largest quantity of sulfur of any of the dusted plats, than in plat 5.

INSECT CONTROL

The degree of infestation by codling moth was reduced by all the treatments given. The least infestation was on the plat dusted with a mixture containing 90 per cent of sulfur. On each of the other two dusted plats the infestation was slightly higher than on the sprayed plat, but the

differences are too small to have any significance. The results in regard to the apples stung were similar. The first application was made too late to be effective against the leaf roller.

RESULTS OF THE EXPERIMENT ON BALDWIN APPLES

DISEASE CONTROL

Fair comparison of the plats of Baldwin apples (table 10) is difficult to make. By picking from a large number of trees in the sprayed plat, a fair average for a plat with light yield was obtained; but unfortunately, owing to the vagaries of the freeze of May 27, the comparison must be made largely with trees having a relatively heavy yield. Three of the trees in the check plat, and all the trees in two of the dusted plats, bore most of their fruit on the protected (south) side. As a consequence the branches bore a very heavy crop of apples. The fruits on these trees hung in a dense mass, they were not well colored (so-called gray Baldwins), and everything was favorable for the spread of fungous diseases. One of the untreated trees (B⁴) bore a light yield of fruit which was evenly distributed over the tree, the apples were very highly colored, and as a result of these conditions the percentage of scab and blotch was relatively low on this tree, with a corresponding lowering in percentage for the plat and increase in the probable error.

The spots recorded for scab were in many cases the result of late infection. This was true even in the check plat. The early scab spots were not very large, and almost all the apples listed as scabby would unquestionably pass for standard "A" grade. With these facts in mind, it may be stated as a deduction from the figures presented in table 10 that the dust mixtures do not adhere to the trees as long as does lime-sulfur solution, and that in a season such as that of 1915 an additional application of powdered sulfur would be needed to give the best results. In ordinary years the last application would be made ten days or two weeks later, and in average years there have not been the numerous infection periods that occurred in 1915. Considering that after the last application the Baldwin apples hung for twelve weeks in repeated rains the percentage of scab for none of the plats is surprisingly high. The amount of scab on the check plat is not nearly so high as for Rhode Island Greenings. This may be attributed in part to the fact that some dust was unavoidably distributed over the Baldwin trees.

The excellent results obtained on Baldwin apples in 1914 with the mixture containing gypsum as a diluent, and the results obtained on Rhode Island Greenings this year, bear out the opinion expressed by Mr. Glidden that the count trees in plats 4 and 5 are decidedly unfair to the experiment. The yields of other trees in these plats rarely exceeded a half bushel of apples and were probably equally unfair in the other direction.

TABLE 10. CLASSIFICATION OF BALDWIN APPLES FROM THE GLIDDEN ORCHARD *

Treatment	Sound		Unsound		Apple scab		Sooty blotch		Codling moth		Stung	
	Num- ber	Per- centage	Num- ber	Per- centage	Num- ber	Per- centage	Num- ber	Per- centage	Num- ber	Per- centage	Num- ber	Per- centage
Untreated (Plat 1)												
650	232	35.69	418	64.31	246	37.85	170	26.15	36	5.54	76	11.69
2,649	1,293	48.81	1,356	51.19	933	35.22	294	11.10	76	2.87	266	10.04
1,448	823	56.84	625	43.16	359	24.79	121	8.36	53	3.66	156	10.77
1,795	1,034	57.60	761	42.40	282	15.71	220	12.26	86	4.79	267	14.87
Mean		49.73		50.27		28.39		14.47		4.22		11.84
Probable error		±3.43		±3.43		±3.43		±2.68		±0.40		±0.72
Lime-sulfur solution 2.5 gallons, lead arsenate 2.5 pounds, water to make 100 gallons (Plat 2)												
80	62	77.50	18	22.50	3	3.75	1	1.25			15	18.75
85	75	88.24	10	11.76				1.18			10	11.76
304	254	83.55	50	16.45	8	2.63	3	0.99			35	11.51
305	278	91.15	27	8.85	4	1.31			4	1.32	21	6.89
93	83	89.25	10	10.75	2	2.15			3	0.98	8	8.60
344	306	88.95	38	11.05	2	0.58					31	9.01
412	380	92.23	32	7.77	4	0.97			4	1.16	31	9.01
561	498	88.77	63	11.23	4	0.71			5	0.49	53	9.45
Mean		87.46		12.54		1.51		0.63		0.61		10.26
Probable error		±1.14		±1.14		±0.29		±0.11		±0.13		±0.94
Sulfur 80, lead arsenate 20 (Plat 4)												
137	90	65.69	47	34.31	15	10.95	5	3.65		0.73	27	19.71
284	230	80.99	54	19.01	18	6.34	5	1.76	1	0.70	30	10.56
1,820	1,295	70.80	524	29.20	247	13.50	156	8.53	20	1.09	159	8.69
1,306	948	72.59	358	27.41	194	14.85	82	6.28	8	0.61	99	7.58
Mean		72.52		27.48		11.41		5.06		0.78		11.64
Probable error		±2.14		±2.14		±1.26		±1.00		±0.07		±1.86
Sulfur 90, lead arsenate 10 (Plat 3)												
679	575	84.68	104	15.32	24	3.53	7	1.03		1.03	69	10.16
350	303	85.11	53	14.89	20	5.62	3	0.84	10	2.81	22	6.18
299	232	77.59	67	22.41	15	5.02	18	6.02	3	1.00	38	12.71
Mean		82.46		17.54		4.72		2.63		1.61		9.68
Probable error		±1.64		±1.64		±0.42		±1.14		±0.40		±1.28
Sulfur 40, lead arsenate 10, gypsum 50 (Plat 5)												
1,963	1,138	57.97	825	42.03	566	28.83	130	6.62		1.83	136	6.93
423	236	55.79	187	44.21	121	28.61	38	8.98		1.42	44	10.40
957	536	56.01	421	43.99	190	19.85	135	14.11		2.19	132	13.79
900	572	63.56	328	36.44	217	24.11	65	7.22		0.67	73	8.11
Mean		58.33		41.67		25.35		9.23		1.53		9.81
Probable error		±1.22		±1.22		±1.44		±1.15		±0.22		±1.02

* In interpreting this table the supplementary data on page 341 must be considered.

INSECT CONTROL

The results of the experiments on Baldwins are very similar to those obtained on the Rhode Island Greenings, as far as codling moth is concerned. The same is true of the stung apples. No count was made of apples injured by the leaf roller.

EXPERIMENTS IN THE McCLEW ORCHARD AT NEWFANE

The experimental orchard at Newfane consisted of a block of Rhode Island Greening and Baldwin trees, with some intermingling of Golden Russets, as shown in figure 76. The orchard is one of the old Niagara

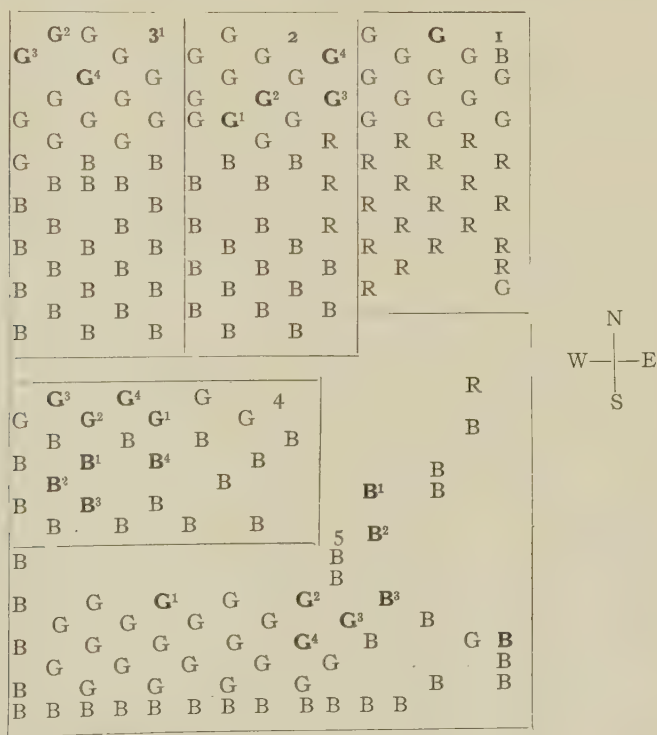


FIG. 76. PLAN OF EXPERIMENTS PERFORMED IN THE McCLEW ORCHARD, NEWFANE, NEW YORK

The blocks of trees enclosed in the black lines represent the various plats as indicated by the numbers in the upper right-hand corners. Plat 4, untreated; plat 2, sprayed; plats 1, 3, and 5, dusted with varying proportions of sulfur mixtures. The trees indicated by bold-faced type are the trees from which apples were counted; the exponents refer to the order in which the data are presented in the table. B, Baldwin; G, Rhode Island Greening; R, Golden Russet

County orchards, set many years ago with the trees spaced too close together. The result of this overcrowding in the orchard has been overcome by removing trees diagonally and by pruning out nearly twenty

feet from the tops of many of the trees. The land is nearly level. The soil is a rich sandy loam, and is well tilled and cultivated every year. It was plowed late in the fall of 1914, and for that reason the trees were not expected to develop as high a percentage of scab as might otherwise be found.

The black lines in the illustration separate the variously treated plats, which are designated by arabic numbers in the upper right-hand corners; the letters set in bold-faced type indicate the trees from which counts were made. The situation of the untreated plat was due to fences and small buildings. Fortunately no dust was carried to the untreated trees in any of the applications.

METHODS AND MATERIALS USED

The spraying solution used in the experiment in this orchard was applied with a power spraying outfit having a pressure of 200 pounds. Two men and a team were used to operate the sprayer. Owing to the shape of the trees only one line of hose could be used to advantage, as the trees could be reached only from a high tower. The dust mixtures were applied with a power outfit operated by a $2\frac{1}{2}$ -horsepower air-cooled engine. The engine was run at a high speed, and extra sections of pipe were added to the outlet tube in order to reach the tops of the trees. With the trees alternating as they do, when driving north and south it was found possible to make the applications by driving once in each row. With the large quantity of material that could be passed through the machine because of high speed of the engine, and by driving only once in the row, it was possible to make some of the applications in a very short time. The records in table 11 for the last two applications in plats 1 and 3 are to be noted particularly.

A thorough treatment with scale-strength lime-sulfur solution was given to the entire orchard at the time when the buds first showed green. Four summer applications were made: the first when the blossoms showed pink, the second when the petals had mostly fallen, the third three weeks later, and the fourth nine weeks after the second.

The treatments in this orchard are of special interest because in most cases the applications were made after storm periods, but usually not so much as twenty-four hours afterward and presumably before infection had actually taken place. The first application, on May 8, followed heavy rain at five o'clock on the afternoon of May 7, and was hindered by wind. The spraying was done at nine o'clock in the morning, but most of the dusting was delayed until seven in the evening. By that time the wind had gone down, but as the work was nearing completion the wind rose and rain began to fall. The outside row in plat 4 was

treated while the rain was falling, one man directing the way with a lantern and another pouring dry sand on the belt to prevent it from slipping. Rain continued well into the night, and, considering the favorable conditions for scab infection the preceding night, it was well that the dusting was finished. Incidentally the time records for this application are of little value. It should be borne in mind that in commercial work the wind might not have been a factor, as the operators could have driven into the wind and with it; but in the experimental work it was necessary to drive north and south.

At the time of the second application, on May 21, rain had fallen at nine o'clock on the preceding night; the dust applications were made twelve hours later, and the spraying was done sixteen hours later. Between the dusting and the spraying a heavy shower of rain fell, and there were other showers in the afternoon. Following the heavy shower, which came shortly after the dusting was completed, some of the dusted foliage was examined carefully. Considerable quantities of the dust were found, even on the upper sides of leaves which had become somewhat smooth.

On June 11 there was heavy rain at one o'clock in the afternoon, and on the morning of June 12 the third application was made. The fourth application was made in the same period of midsummer rain as is recorded for the other orchards.

The dust applications were planned to test the effectiveness of different quantities of sulfur per tree on the direct basis of applying a small quantity, and to determine whether a mixture containing the essential adhesives in cold-water paint, namely, casein and lime, might increase the effectiveness of the mixture.

In table 11 are shown the dates, quantities of material used, and other data, for the different applications. The cost figures are calculated on the same basis as for the Mitchell orchard (page 315). Figures for the cold-water paint mixture are not inserted, as no estimates were obtained on the basis of a large quantity.

The average time per tree for spraying in this orchard, 1.5 minutes, is very low. The quantity of material applied per tree accounts for this in part. As the set of fruit was very light in plat 2, and as it was confined to certain branches which were well loaded, the loaded branches were sprayed thoroughly and the remainder of the trees received what is commonly known as a general treatment.

The average time per tree for applying the dust in each application was 0.486 minute, or more than three times as fast as trees could be sprayed. When the time for filling the tank and for driving to and from the orchard is added, the difference is marked.

TABLE II. DATA ON TIME AND METHODS OF APPLICATION, MCCLEW ORCHARD, NEWFANE, NEW YORK

Date of application	Plat	Num-ber of trees	Material used, and strength	Quan-tity used	Time required						Cost		
					Horse		Man		Machine		Labor	Ma-terial	Total cost
					Hrs.	Min.	Hrs.	Min.	Hrs.	Min.			
May 8	2	35	Lime-sulfur solution 2.5	(Gallons)	2	00	2	00	1	00	\$.60	\$.75	\$1.35
May 21	2	35	gallons, lead arsenate	100	2	00	2	00	1	00			
June 12	2	35	2.5 pounds, water to	100	1	40	1	40	0	50	.60	.75	1.35
July 22	2	35	make 100 gallons	100	1	40	1	40	0	50	.50	.75	1.25
Total..	...	...	.....	400	7	20	7	20	3	40	\$2.20	\$3.00	\$5.20
May 8	3	37	Sulfur 80, lead arsenate	(Pounds)	1	04	1	04	0	32	\$.32	\$5.29	\$5.61
May 21	3	37	20	90	0	34	0	34	0	17	.17	4.70	4.87
June 12	3	37		80	0	24	0	24	0	12	.12	4.12	4.24
July 22	3	37		70	0	24	0	24	0	12	.12	3.53	3.65
Total..	...	...	.....	300	2	26	2	26	1	13	\$.73	\$17.64	\$18.37
May 8	5	61	Sulfur 90, lead arsenate	(Pounds)	1	04	1	04	0	32	\$.32	\$9.59	\$9.91
May 21	5	61	10	220	1	02	1	02	0	31	.31	5.85	6.16
June 12	5	61		180	1	00	1	00	0	30	.30	10.46	10.76
July 22	5	61		240	0	48	0	48	0	24	.24	6.10	6.34
Total..	...	...	.....	780	3	54	3	54	1	57	\$1.17	\$32.00	\$33.17
May 8	1	33	Sulfur 75, lead arsenate	(Pounds)	0	50	0	50	0	25	\$.25		
May 21	1	33	10, casein and lime 15	120	0	32	0	32	0	16	.16		
June 12	1	33		100	0	20	0	20	0	10	.10		
July 22	1	33		120	0	28	0	28	0	14	.14		
Total..	...	...	.....	460	2	10	2	10	1	05	\$.65		

The average amount of the essential ingredients applied per tree each time is of interest. These are: for the plat sprayed with lime-sulfur solution, 2.68 ounces of sulfur and 1.14 ounces of arsenate of lead; for the plat receiving the 80-20 mixture, 26 ounces of sulfur and 6.48 ounces of arsenate of lead; for the plat receiving the 90-10 mixture, 46 ounces of sulfur and 5.11 ounces of arsenate of lead; and for the plat dusted with the mixture containing casein and lime, 41.82 ounces of sulfur and 5.6 ounces of arsenate of lead. The figures for the sprayed plat are exceptionally low, but if there had been a good set of fruit at least double this amount of material would have been required.

DISEASES OF THE SEASON

Unfortunately for the experiment, the apple scab fungus did not develop abundantly in this orchard, presumably for the same reasons as were suggested for the Rogers orchard (page 325). On June 12 the first scab infections were found. These were in the untreated plat and were very few in number. Sooty blotch had not appeared to any extent at the time when the Rhode Island trees were harvested, September 16 and 17, but by the time the Baldwins were harvested, October 13 and 14, the number of blotched apples was greatly increased.

INSECTS OF THE SEASON

With the exception of codling moth and a small infestation of leaf roller, this orchard was nearly free from injurious insects.

RESULTS OF THE EXPERIMENT ON RHODE ISLAND GREENING APPLES

There were no apples on the ground at picking time except such as were dropped by the pickers, and these were not examined. The record for the Rhode Island Greening apples in the orchard is shown in table 12. It may be seen that the amount of scab, even on the check trees, was comparatively low. In the control of codling moth all the treatments gave nearly equal results, and the same is true in regard to the apples stung. Unfortunately the small number of apples on the sprayed plat makes comparison unsafe.

In the case of this orchard the figures presented in the table do not represent the commercial aspects of the situation at all. From the table it appears that nearly 7 per cent of the apples from plat 3 were affected with scab. It is very doubtful, however, whether a single apple was discarded because of the disease. Mr. McClew stated that the apples in plat 5 were the finest, largest, and cleanest apples he had ever taken from it.

RESULTS OF THE EXPERIMENT ON BALDWIN APPLES

DISEASE CONTROL

As in the Glidden orchard, the results obtained with Baldwins in this orchard are not so good as those for Rhode Island Greenings. Unquestionably this may be attributed to the frequent infection periods during August and September, and to the fact that the Baldwins hung on the trees for a month longer than the Rhode Island Greenings. The comparison of plats of Baldwins is as unsafe as the comparison of plats of Rhode Island Greenings. The number of trees bearing fruit was small, and the yield of some trees was too low to be of much value. The apples from one large tree in plat 5 were counted, but they ran so high in scab and blotch as to make the count obviously unfair. The tree is on the roadside and was usually treated from one side only – and that was the side not bearing fruit. The results of the experiment are shown in table 13, and graphically in figure 77.



FIG. 77. GRAPHIC REPRESENTATION OF THE PERCENTAGE OF CONTROL OF INSECTS AND DISEASES IN THE VARIOUS PLATS OF THE MCCLEW BALDWIN ORCHARD

U, untreated; S, sprayed; 80-20, sulfur 80 per cent, lead arsenate 20 per cent; 90-10, sulfur 90 per cent, lead arsenate 10 per cent; P, perfect; St, stung; C, codling moth; Sc, scab; B, blotch

INSECT CONTROL

In this orchard, apparently better results were obtained in the control of codling moth with the spray than with the dust. As shown in the table, however, there were less than half as many stung apples on the untreated plat as on the treated plats. In view of this fact, it is unsafe to draw definite conclusions from the experiment.

TABLE 13. CLASSIFICATION OF BALDWIN APPLES FROM THE McCLEW ORCHARD

Treatment	Total number of apples	Sound		Unsound		Apple scab		Sooty blotch		Coding moth		Stung	
		Num-ber	Per-centage	Num-ber	Per-centage	Num-ber	Per-centage	Num-ber	Per-centage	Num-ber	Per-centage	Num-ber	Per-centage
Untreated (Plat 4)	2,914	793	27.21	2,121	72.79	468	16.06	1,432	49.14	460	15.79	267	9.16
	1,178	484	41.09	694	58.91	35	2.97	397	33.70	253	21.48	96	8.15
	1,558	364	23.36	1,194	76.64	321	20.60	864	55.46	193	12.30	124	7.96
	1,281	313	24.43	968	75.57	344	26.85	622	48.56	163	12.88	121	9.45
	.....	.....	29.02	.....	70.98	.....	16.62	.....	46.72	.....	15.64	.....	8.68
Probable error.....	.....	.....	±2.77	.....	±2.77	.....	±3.41	.....	±3.11	.....	±1.41	.....	±0.02
Lime-sulfur solution, 2.5 gallons, lead arsenate 2.5 pounds, water to make 100 gallons (Plat 2)	381	316	82.94	65	17.06	10	2.62	24	6.30	2	0.52	31	8.14
	599	449	74.90	150	25.04	14	2.34	21	3.51	13	2.17	103	17.20
	200	144	72.00	56	28.00	3	1.50	14	7.00	4	2.00	38	19.00
	384	281	73.18	103	26.82	1	0.26	11	2.86	20	5.21	74	19.27
	249	195	66.27	84	33.73	3	1.20	8	3.21	16	6.43	59	23.69
Mean.....	.....	.....	73.87	.....	26.13	.....	1.58	.....	4.58	.....	3.27	.....	17.46
Probable error.....	.....	.....	±1.82	.....	±1.82	.....	±0.03	.....	±0.53	.....	±0.74	.....	±1.73
Sulfur 80, lead arsenate 20 (Plat 3)	1,016	767	75.49	249	24.51	4	0.39	27	2.66	47	4.63	169	16.63
	196	144	73.47	52	26.53	.....	.....	2	1.02	9	4.59	43	21.94
	307	224	72.96	83	27.04	2	0.65	2	0.65	24	7.82	56	18.24
	231	169	73.16	62	26.84	.....	.....	5	2.16	16	6.93	42	18.18
	535	389	72.71	146	27.29	10	1.87	8	1.50	37	6.92	99	18.50
Mean.....	.....	.....	73.56	.....	26.44	.....	0.58	.....	1.60	.....	6.18	.....	18.70
Probable error.....	.....	.....	±0.31	.....	±0.31	.....	±0.23	.....	±0.25	.....	±0.45	.....	±0.59
Sulfur 90, lead arsenate 10 (Plat 5)	478	233	48.74	245	51.26	30	6.28	34	7.11	86	17.99	107	22.38
	268	155	74.52	53	25.48	2	0.96	7	3.37	10	4.81	37	17.79
	365	283	77.53	82	22.47	1	0.27	12	3.29	8	2.19	61	16.71
	.....	.....	65.03	.....	33.97	.....	2.50	.....	4.59	.....	8.33	.....	18.06
	.....	.....	±1.24	.....	±1.24	.....	±1.28	.....	±0.60	.....	±2.32	.....	±0.83
Mean.....	.....	.....	65.03	.....	33.97	.....	2.50	.....	4.59	.....	8.33	.....	18.06
Probable error.....	.....	.....	±1.24	.....	±1.24	.....	±1.28	.....	±0.60	.....	±2.32	.....	±0.83

SUMMARY

The results of primary considerations from the experiments of 1915 may be summarized as follows:

1. A reduced quantity of arsenate of lead in a dust mixture may be depended upon to give good results. In the Mitchell orchard, where 29 per cent of the untreated apples were attacked by codling moth larvæ, the percentage of infestation was lower on both the dusted plats than on the sprayed plat, in spite of the fact that less lead arsenate was applied per tree in each of the dusted plats. The only possible explanation for the superior results obtained on the dusted plats lies in the better distribution effected by the dust method.

In the Jungbluth orchard, the percentage of codling moth injury on the plat dusted with the 90-10 mixture, in which the trees received 3.5 ounces of arsenate of lead in each application, is about the same as for the sprayed plat, in which the trees received only slightly less lead arsenate in each application (3.06 ounces). In the plat dusted with the mixture containing hydrated lime, the amount of lead arsenate used per tree was less than in the sprayed plat, and yet the percentage of injury is less than half that on the sprayed plat. As a generalization it may be said that from two to three ounces of arsenate of lead per tree for each application is sufficient to suppress the common insects that are controlled by a poison.

2. The experiments indicate that 15 ounces of finely ground sulfur applied per tree in each application will give effective control of the scab disease and of sooty blotch. So far as can be determined, the sulfur can be applied directly in this amount, although the results with Rhode Island Greening trees in the Glidden orchard would indicate that the use of a filler allows for better distribution. This factor will probably vary with the size, shape, and density of foliage of the trees to be treated.

The experiments show further the fact, already indicated in previous work, that powdered sulfur applied dry does not adhere as well as sulfur applied in liquid form as lime-sulfur solution, or as the very fine sulfur precipitated from a solution on the addition of arsenate of lead or an acid substance. In every case but one in which scab was a factor, the percentage of scab on the dusted plats was greater than on the sprayed plats, though in some cases the difference is insignificant.

3. There is no indication that the dust mixtures have been improved by the addition of any of the diluents used. In fact it would scarcely be possible to get better results than were obtained with some of the dust mixtures containing the pure ingredients. In the Rogers orchard, apples from the plat dusted with the mixture containing soap were not counted, because better results than were obtained with the 90-10 mixture could

not be expected. The trees were examined closely and it was evident that green and rosy aphid had not been killed by the treatment.

4. The low percentages of scab or codling moth, or both, on treated plats as compared with the fairly high percentages on untreated plats, indicate that the applications were made at critical times. It may be said that the infection periods were so numerous during the summer that none of the applications were made many days before such a period. Nevertheless, as actual experience shows, many growers fail to make applications at critical times, with the result that much of the fruit is scabby and wormy.

GENERALIZATIONS

It now seems settled that a mixture of an insecticide and a fungicide can be applied in powdered form, using air as a carrier, with better commercial results in the control of preventable apple diseases and of apple insects than can be obtained by spraying. At the same time, the dust method makes it possible for the owner of a large acreage to protect his orchard at critical times, a thing that he has not been able to do with the slow liquid process.

The method seems to be adapted to conditions as they exist in apple orchards in most parts of New York. The only objection at present to the complete substitution of the dust method for spraying in these sections is that there is no known dust preparation now available which will kill scale insects, and no dust preparation which is effective against such insects as aphid and pear psylla. It may be confidently stated that when as much time and effort has been expended in developing a dry preparation for killing these insects as has been devoted to developing spraying methods for their control, such a preparation will be found. In the meantime those persons who must spray for scale and for aphid and who can cover their orchards in two days, will do well to continue with the liquid method. Those who cannot cover their orchards in less than a week or in two weeks will find much needed relief in the dust method, which admits of operation with one team, or even two teams, less, or allows for more extensive and better cultivation of field crops.

In those sections of the State where San José scale does not exist — as, for example, in the Wyoming Valley — the dust method might be adopted with great benefit. In general the trees in this valley are very old and unusually large, thus discouraging the use of a sprayer. The dust may be blown to the tops of the highest trees, and with air for a carrier perfect distribution can be secured.

MATERIALS USED, AND STRENGTH

In all the experiments a powdered sulfur of unusual fineness was used. It is believed that the effectiveness of the treatment in scab control

depends on the exceeding fineness of the sulfur; this opinion is based on the fact that the sulfur from the disintegration and precipitation of lime-sulfur solution is in an exceedingly fine state of division. The powdered lead used in the experiments was of the so-called fluffy type.

It appears from the experiments that for average western New York conditions good results can be obtained if a mixture containing 85 per cent of exceedingly finely ground sulfur and 15 per cent of powdered arsenate of lead is applied to the trees at the proper times, in amounts of from 1.25 to 2.5 pounds per tree in each application. The exact quantity of material to be used for each tree will be determined by the size and the shape of the trees, and also by the thoroughness of distribution effected (Figs. 78 and 79). If there is much wind, more of the dust will be blown away from the trees than if the application is made in calm weather. In localities where apple scab is less abundant than in the lake counties, as seems to be the case in most of the Hudson River section, the quantity of sulfur applied per tree may be reduced. Until one has become expert at dusting, the desired result can best be obtained by substituting 50 pounds of terra alba for 50 pounds of sulfur. The quantities suggested seem to be ample, and slightly in excess of the quantities used in some of the experiments. It would be well, however, to regard these as minimum amounts until experience has shown that they can be reduced with safety.

METHOD OF APPLICATION

In all the experimental work the trees have been treated from two sides, either by driving twice in each row, or, in the case of trees set on the quincunx plan, by swinging the outlet pipe alternately from one side of the machine to the other. The handling of the outlet pipe to effect thorough distribution depends much on the shape of the tree. In many cases the most satisfactory method is a steady up-and-down sweep of the outlet (Fig. 78). For a large tree of great height and expanse a long outlet pipe should be used, and the pipe should be swung over the tree in a semicircle from the lower branches to the top; this insures reaching the fruit in the top of the tree (Figs. 80 and 81). That part of a large tree which is least likely to be treated properly is the branches that are nearest the machine. Because of the long outlet pipe these cannot be reached until after the machine has passed the tree.

In commercial work it is possible to make applications without regard to the direction of the wind (Fig. 82). For most New York orchards the wind is likely to be in the east or in the southeast on the days when the applications can be made to greatest advantage so far as scab control is concerned. If the wind is in the east the application should be made by driving east and west. If for any reason it is desirable to make applications first from one side and then from the other, it would be possible to dust with the wind, just as most growers now spray with the wind.

THOROUGHNESS OF APPLICATION

From the fact that a cloud of dust can be seen floating over the orchard, many persons are likely to infer that the orchard may be treated by driving only once in a row, or perhaps by driving in every other row (Fig. 83). In all the experiments reported, the treatments have been made by applying the dust from each side of every row of trees. In the case of two roadside trees in plat 5 of the McClew orchard, the applications of dust were of necessity made from one side only, and that was not the side on which the trees bore fruit. In order to make a count from four Baldwin trees in this plat, it was necessary to take apples from one of these trees. The results were so different from those from other Baldwin trees in the plat, and from the Rhode Island Greening trees in the same plat, that they were not included in the table because they were obviously unfair.

On this roadside tree the percentages of injured apples were as follows: from scab, 26 per cent; from blotch, 23 per cent; from codling moth, 8 per cent; from stings, 11 per cent. It is evident that there was as large a percentage of scabby apples on this tree as on the most severely affected tree in the untreated plat. The dissimilarity in control of blotch may be accounted for readily by the fact that the last application was more thorough than the preceding ones. The surrounding oats had been cut, and the wind was from a favorable direction.

The figures show very convincingly that large trees must be treated from both sides.

TIME OF APPLICATION

The time of application of dust mixtures for the control of apple diseases and insects does not differ from the time of application of sprays. It is possible, however, to make applications of dust at unusual times in order to meet special conditions. In future experimental work it may develop that more frequent applications, using much smaller quantities of material each time, will give greater satisfaction. This seems very probable.

The time of day when the dust is applied is of little consequence. There is no special advantage in applying dust when the dew is on the foliage, except for the fact that the presence of dew is a good indication of a calm atmosphere. Under such a condition dust may be applied just as fast as a team can be driven through the orchard. An experienced operator can manipulate the outlet pipe in such a way as to cover the tree completely, and may be sure that the air current furnished by the blower will carry the materials where they are needed (Fig. 84). This condition, however, is no better than the misty, foggy day following a heavy rain, such as has occurred repeatedly during the past summer.



FIG. 78. TREATING A VERY LARGE BALDWIN APPLE TREE

On trees of this shape, the dust can be distributed by long vertical sweeps of the outlet pipe. The position of the dust indicates that the third sweep has just been completed



FIG. 79. DUSTING A LARGE RHODE ISLAND GREENING TREE

On Rhode Island Greening trees the dust can be distributed by horizontal sweeps of the outlet pipe



FIG. 80. DUSTING A LARGE BALDWIN APPLE TREE
The top of the tree has been finished, and a long sweep of the outlet pipe has been made to take in the lower branches



FIG. 81. DUSTING A LARGE TWENTY OUNCE APPLE TREE
On trees of this type the outlet tube is brought quickly to the top of the tree. This is particularly necessary when the wind is blowing, in order to reach the top



FIG. 82. DUSTING A RHODE ISLAND GREENING APPLE TREE

The dust cannot be driven far against the wind. When the wind is blowing it is much better to apply the dust across the wind, driving with and into it



FIG. 83. APPLICATION OF DUST BEFORE THE BLOSSOMS OPEN

The cost of material for dusting is greater than for spraying because much of the dust does not reach the tree. The presence of a dense fog of dust in an orchard is no indication that the trees are receiving thorough protection. The dust must be applied to the trees from both sides



FIG. 84. DUSTING A LARGE BALDWIN APPLE TREE
On a calm day the dust can be distributed perfectly

The dust method also offers relief to growers who are never able to predict the probable arrival of a storm period. As a general rule, it is probably better to make the applications at critical times before storm periods; but in case this is not done, it is perfectly possible to secure nearly complete protection by making an application within twelve, or possibly even eighteen, hours after the first fall of rain of a general storm period. In most instances during the summer of 1915 this has been practicable.

HOME MIXING OF MATERIALS

It now appears that materials for dusting can be procured in bulk and the mixtures economically prepared at home. In order to make a suitable mixture it is absolutely necessary to have a mixing machine. A machine operated by hand has sufficient capacity for the average orchardist, but for large quantities, as in the case of associations of growers mixing at a central station, a large mixer operated by a gasoline engine would prove more satisfactory. With a supply of the essential materials on hand, a mixture can be made on short notice to meet a special condition. The sudden outbreak of an insect pest or of a fungous disease might call for an application of one or the other of the essential ingredients alone, in which case it could be mixed with an inert filler, such as hydrated lime or terra alba. This would be necessary in the case of arsenate of lead in order to provide bulk, and in the case of sulfur in order to improve the flowing qualities.

APPLICABILITY OF THE DUST METHOD

So far the dust method has been tested thoroughly, under New York conditions, only on apples. Whether the method can be extended to other crops is a question to be determined by experimentation. It may be said in a general way that there are indications of the applicability of the method for a number of other crops.⁶ It is certain, however, that pure dust mixtures—that is, mixtures without a diluent—cannot be used on some varieties of grapes, because of injury to the vines⁷ from the too vigorous action of pure sulfur.

EQUIPMENT

Aside from the dusting and mixing machines no special equipment is needed for the dust method. Any gasoline engine of sufficient power can be arranged to run the dusting machine. Additional pieces of outlet pipe are convenient for use when very high trees are to be treated.

Both driver and operator should be provided with tightly fitting goggles, to prevent the sulfur from getting into the eyes. The goggles should be

⁶ Stewart, V. B. Dusting nursery stock for the control of leaf diseases. Cornell Univ. Agr. Exp. Sta. Circ. 32 : 1-10. 1916.

⁷ Reddick, Donald, and Gladwin, F. E. Powdery mildew of grapes and its control. Int. Vit. Cong. Proc.—. 1915. (In press.)

put on before any work is done and should be kept on all the time. They should not be raised for any purpose. At meal time it is well not to wash the eyes at all, nor rub them with hands or towel. It is also a wise precaution to wash the eyebrows well with water before removing the goggles. In this way the dust can be kept from the eyes and the resulting discomfort avoided. The slightest quantity of the mixture in the eyes will cause just as much discomfort as will a large quantity. The smarting usually does not come for some time, often not for several hours, after the dust enters the eyes. The trouble is not due to poisoning, but is merely irritation of the eyeballs by the fine sulfur. A copious flow of tears is finally produced, and the irritant is thus washed out.